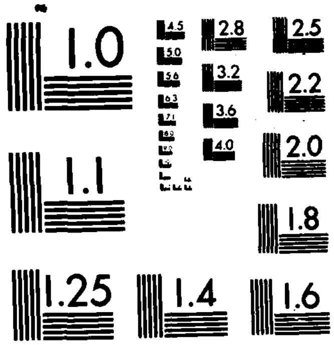
AD-A165 520 CONTROLLING LIFE-CYCLE COST: A MANAGEMENT PERSPECTIVE 1/2
(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA D L PORTER
DEC 85

UNCLASSIFIED F/G 5/1 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3

(2)

NAVAL POSTGRADUATE SCHOOL

Monterey, California

AD-A165 520

THESIS

CONTROLLING LIFE-CYCLE COST:
A MANAGEMENT PERSPECTIVE

by

David L. Porter

December 1985

Thesis Advisor: D. V. Lamm

Approved for public release; distribution is unlimited.

SECURITY CLASSIFICATION OF THIS PAGE — AD-A165520

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION: Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION: Naval Postgraduate School; 6b. OFFICE SYMBOL (If applicable): Code 54	7a. NAME OF MONITORING ORGANIZATION: Naval Postgraduate School
6c. ADDRESS (City, State, and ZIP Code): Monterey, California 93943-5004	7b. ADDRESS (City, State, and ZIP Code): Monterey, California 93943-5004
8a. NAME OF FUNDING/SPONSORING ORGANIZATION; 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

CONTROLLING LIFE-CYCLE COST: A MANAGEMENT PERSPECTIVE

12. PERSONAL AUTHOR(S)

PORTER, DAVID L.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Master's thesis	FROM ____ TO ____	1985 December	148

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Life-cycle cost management; total cost of ownership; managing cost; operating and support cost; LCC of aviation support equipment

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The objective of this research is to examine the obstacles which are preventing the Navy from realizing the full economic advantage of a total cost management program for aviation support equipment. The research has shown that Navy program managers are not fully committed to managing life-cycle cost nor is it considered early enough in the procurement process to influence design. To improve the life-cycle cost management effort, existing policies and provisions included in DoD Directives should be applied to aviation support equipment. More emphasis should be placed on the RFP as a means of communicating the Navy's concerns about controlling cost and adequate information should be provided to the contractor to be used in developing realistic cost estimates. Finally, life-cycle cost should be elevated to the level of unit-production cost, schedule and performance and made a mandatory source selection criterion.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL: D. V. Lamm	22b. TELEPHONE (Include Area Code): (408) 646-2775; 22c. OFFICE SYMBOL: Code 54Lt

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete. — SECURITY CLASSIFICATION OF THIS PAGE

Approved for public release; distribution is unlimited.

Controlling Life-Cycle Cost: A Management Perspective

by

David L. Porter
Lieutenant Commander, United States Navy
B.A., University of Louisville, 1976

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
December 1985

Author: David L. Porter

Approved by: D. V. Lamm, Thesis Advisor

R. W. Smith, Second Reader

W. R. Greer Jr., Chairman,
Department of Administrative Sciences

Kneale T. Marshall
Dean of Information and Policy Sciences

ABSTRACT

The objective of this research is to examine the obstacles which are preventing the Navy from realizing the full economic advantage of a total cost management program for aviation support equipment. The research has shown that Navy program managers are not fully committed to managing life-cycle cost nor is it considered early enough in the procurement process to influence design. To improve the life-cycle cost management effort, existing policies and provisions included in DoD Directives should be applied to aviation support equipment. More emphasis should be placed on the RFP as a means of communicating the Navy's concerns about controlling cost and adequate information should be provided to the contractor to be used in developing realistic cost estimates. Finally, life-cycle cost should be elevated to the level of unit-production cost, schedule and performance and made a mandatory source selection criterion.

TABLE OF CONTENTS

LIST OF FIGURES

ACKNOWLEDGEMENT

The preparation of a Master's Thesis is a very demanding undertaking, requiring a great deal of personal sacrifice. The sacrifices are not only made by the students, but their families as well. I am deeply indebted to my wife, Susan, and my sons, Michael and Bobby, for their support during my tour at the Naval Postgraduate School. Without their love and understanding my tour would not have been nearly as successful.

I. INTRODUCTION

A. FOCUS OF THIS STUDY

To field a weapon system in today's environment is an expensive proposition to say the least. Prices are increasing and the acquisition process is coming under increased scrutiny by Congress. In such an atmosphere, the Navy needs to seek more efficient methods of acquiring and operating the weapon systems needed to fulfill the foreign policy objectives of the United States. One method of accomplishing this is by seeking better ways of managing and controlling the life-cycle cost of systems and subsystems.

B. OBJECTIVE

The intent of this thesis is to examine the obstacles which are preventing the Navy from deriving the full economic advantage of managing life-cycle costs for aviation support equipment. It is directed towards management level personnel, (program managers and contracting officers), and is not intended to be a detailed discussion of the procedures used to accumulate life-cycle cost data or of the analytical techniques used in evaluating these data. Emphasis is placed on management's approach to controlling life-cycle costs and is limited to the acquisition of aviation systems and, in particular, aviation support equipment.

C. RESEARCH QUESTIONS

In consonance with the above stated objective the following research question was addressed: What are the obstacles which are preventing the Navy from minimizing life-cycle costs in the acquisition of aviation support equipment?

In support of the primary research question the following secondary questions were addressed:

* What are life-cycle costs and how have they been controlled?
* What legislation or regulations have been proposed or are anticipated concerning life-cycle cost and what effect might these laws and regulations have in minimizing life-cycle costs?
* What is industries perception of the obstacles which might be overcome in order to minimize life-cycle costs?
* What internal action can the Navy take to overcome these obstacles?
* How can industry be encouraged or incentivized to minimize life-cycle cost?
* What has the Navy done to minimize life-cycle cost?
* What specific actions could the Navy take to reduce life-cycle costs for aviation support equipment?

D. RESEARCH METHODOLOGY

The primary methods of research to support this study have been an in-depth literature search, and personal and telephone interviews with industry and Navy representatives. Personal interviews were conducted with representatives of Lockheed, Teledyne and Litton Guidance and Control Systems. On the Navy side, personal interviews were conducted with personnel at the Naval Air Systems Command Headquarters and the Naval Air Logistics Center, Pautuxent River, Maryland. Numerous telephone interviews were also conducted with Navy representatives at NAVAIR.

E. SCOPE OF THE STUDY

The management of ownership costs for support equipment is addressed from two directions. Since support equipment is a significant portion of the operating and support costs of a major system, emphasis is first placed on controlling life-cycle cost at the system level. Secondly, recognizing that support equipment has a life-cycle of its own, the management of the ownership costs of the support equipment itself will be addressed.

The thesis specifically examines the obstacles to managing life-cycle cost as viewed by support equipment contractors in the aerospace industry and by Navy and civilian officials of the Department of Defense. This thesis will also offer recommendations to increase the effectiveness of life-cycle cost management in the acquisition of aviation systems and support equipment.

F. LIMITATIONS

No limitations were encountered while conducting this research.

G. ASSUMPTIONS

Throughout this research report, it is assumed that the reader is familiar with the Federal Acquisition process and has a general understanding of life-cycle cost. It is further assumed that the reader is familiar with basic Naval terminology and with basic contracting and acquisition terminology.

H. DEFINITIONS

For the purpose of this thesis, the term life-cycle cost (LCC) will be used synonymously with ownership costs, total cost of ownership and unless otherwise specified "cost" will refer to LCC vice unit-production cost (UPC). Life-cycle cost is defined as:

> The sum total of the direct, indirect, recurring, non-recurring, and other related costs incurred, or estimated to be incurred in the design, research and development (R&D), investment, operation, maintenance, and support of a product over its life cycle, i.e., its anticipated useful life span. It is the total cost of the R&D, investment, O&S and, where applicable, disposal phases of the life cycle. All relevant costs should be included regardless of funding source or management control. [Ref. 1:p. 5]

I. ORGANIZATION

This thesis is divided into an introduction, two background chapters, a chapter detailing the regulatory framework for managing cost, three chapters discussing the problem and solutions as perceived by industry and Government representatives and a final chapter of conclusions and recommendations. Chapters II and III define what is meant by life-cycle cost management and some of the methods of controlling costs which have been employed in the past. Chapter IV discusses the Directives which outline the policies and procedures to be followed in managing life-cycle cost. Chapter V relates the obstacles to managing ownership costs as perceived by representatives of the aerospace industry and Chapter VI is a discussion of possible solutions. Chapter VII addresses the problem from the point of view of the Navy. Chapter VIII presents the conclusions and recommendations of this study.

Each chapter is structured to answer one or more of the research questions with the answer being stated in the chapter summary. A separate summary of answers to research questions is therefore not provided.

The appendix is a list of acronyms used throughout the text.

II. LIFE-CYCLE COST MANAGEMENT

This chapter provides the background necessary for understanding life-cycle cost management and its application to aviation systems. The magnitude of life-cycle cost is presented, including its cost elements included and the various techniques of estimating these costs. A brief overview is presented of the organizational structure of the Support Equipment Division, Naval Air Systems Command and how it is structured to analyze life-cycle costs.

A. THE MAGNITUDE OF LIFE-CYCLE COST

In an era of rising costs and increasing scrutiny of the procurement system, the Department of Defense (DoD) has adopted an affordability acquisition policy. [Ref. 1:p. 8] The system must be affordable not only in terms of unit-production cost, performance and schedule, but also in terms of the total cost of ownership.

The ratio of operating and support cost to the total cost of ownership varies depending on the author. All are in agreement though, that downstream acquisition costs are a considerable portion of total life-cycle costs. One source states, ". . . funds required in supporting a system are often twice those spend in acquiring it." [Ref. 2:p. 36] Another source claims, "Typical system operation and support costs regularly exceed initial development by a factor of 10 to 1." [Ref. 3:p. 1] As substantial as these costs are, they are largely determined early in the life of a system. An Air Force Systems Command study concluded that "85% of weapon system lifetime costs are locked in by the time the decision is made to begin full scale development." [Ref. 4: p. 32]

Aviation support equipment plays heavily in determining the total cost of a system. Not only is support equipment the second largest budget program at the Naval Air Systems Command [Ref. 5:p. 26] but it may account for 10% to 50% of the cost of the prime equipment. [Ref. 6:p.88]

It can be concluded from the figures just quoted that downstream costs are significant. The Navy recognizes this and supports the position that "LCC should be an integral part of management's cost control and reduction efforts." [Ref. 1:p. 5]

The essence of life-cycle cost (LCC) management is best summed up in a quotation from A. M. Frayer of the Office of the Assistant Secretary of Defense. "First design for support; then support the design." [Ref. 7:p. 40] Controlling and managing the total cost of ownership of a system does not mean that the lowest cost is necessarily the most viable alternative. What it does mean is that "LCC management seeks to maintain a balance among the principal acquisition objectives of performance, schedule, cost and supportability." [Ref. 8:p. 1-3] It should be established early that developing LCC estimates is not an attempt to predict the future but is an attempt to plan wisely for future situations. [Ref. 6: p. 117]

The principal application of life-cycle cost has been explained as follows: "It gives quantitative guidance in the program and project office for making tradeoffs among manpower, cost, schedule, performance and logistic support." [Ref. 1:p. 5]

Other sources describe the management effort as " . . . a search for the significant costs that can be influenced by planning and design decisions." [Ref. 6:p. 18] Still another author portrays the effort as ". . . a control method intended to stimulate long term contractor interest in an acquisition effort." [Ref. 1:p. 21]

Don Earles, Manager, Life-Cycle Analysis, Raytheon Co., Huntsville, Alabama, recognizes the impact that total cost management has throughout the procurement process by observing that:

> Life-cycle costing is a costing discipline, a procurement technique, an acquisition consideration and a tradeoff tool.
>
> As a costing discipline it is primarily concerned with operating and support (O&S) cost-estimating methods. As a procurement technique it is concerned with minimizing total life costs for component procurements. As an acquisition consideration its primary concerns are source selection and the balancing of acquisition and ownership costs. As a tradeoff tool its primary concerns are repair levels and the impact of specific design features on operating and support costs. [Ref. 9:p. 39]

There are three basic elements to a life-cycle cost management program: a methodology, a command and easy-to-use LCC analysis framework tailored for use on each acquisition, and procurement techniques that permit bias-free competition. [Ref. 10:p. 377]

> The methodology provides a structure for design analysis to reduce life-cycle costs. This methodology is supported by early testing and engineering analysis where it can do the most good and is backed up by contractual incentives to improve operational reliability. [Ref. 10:p. 377]

The third element in the program is procurement techniques which includes ". . . independent agency review and assessment, and feedback of LCC inputs from the test program where appropriate." [Ref. 10:p. 377]

Closely related to life-cycle cost management is the concept of design-to-cost (DTC). Although Directives define DTC as a balance between total cost of ownership, schedule and performance, the term is used by many managers to mean design to unit production cost. [Ref. 11] Design-to-cost is formally defined in the Federal Acquisition Regulation as follows:

> Design-to-cost is a concept that establishes cost elements as management goals to achieve the best balance between life-cycle cost, acceptable performance, and schedule. Under this concept, cost is a design constraint during the design and development phases and a management discipline throughout the acquisition and operations of the system or equipment. [Ref. 12:p. 7-1]

The magnitude of life-cycle cost is significant, with some estimates for operating and support costs exceeding acquisition costs by a ratio of 10 to 1. Support equipment has been estimated to account for 10 to 50 percent of the cost of the prime equipment. Recognizing the magnitude of ownership costs, the Navy is seeking to maintain a balance between acquisition objectives of performance, schedule, cost and supportability. Design-to-cost, although often referred to as design-to-unit-production cost, is one program to manage the total cost of ownership of a system.

B. COSTS INCLUDED IN THE TOTAL COST OF OWNERSHIP

"The foundation of any life-cycle cost program is an estimate of total program costs which can be used to identify the major cost drivers." [Ref. 10:p. 377] The costs typically included are research and development (R&D), acquisition, operating and support (O&S) costs and the cost of disposal with the interest focusing principally on future costs regardless of whether or not they are under the acquisition manager's control. [Ref. 1:p. 27] Special attention is given to those major cost drivers that can be influenced by planning and design decisions with the question of cost relevancy being unique for each acquisition. [Ref. 1:p. 27]

Research and development costs are generally the first incurred and include R&D for peculiar support equipment (PSE). R&D costs are defined as follows:

> All of the expenses incurred during the concept exploration, demonstration/validation, and full scale development phases of the acquisition which result in the engineering drawings, specifications, and other documents necessary to enter the investment phase of the life cycle are classified as R&D costs. [Ref. 1:pp. 27-28]

Investment costs are usually incurred during the production and development phase and include expenditures for the major system and both common and peculiar support equipment. [Ref. 1:p. 28]

Operating and support costs are usually the largest part of the total cost of ownership and are broken into two phases; deployment and operations and recurring support [Ref. 6:p. 67]. The deployment phase includes initial non-recurring costs such as training and provisioning while the operating and support phase includes the costs incurred during the use of a system [Ref. 6:p. 67]. The various elements included in operating and support costs are: ". . . personnel, material, and overhead costs used in operating a system or equipment or in providing the services required to support the system." [Ref. 1:p. 28]

A detailed discussion of the elements and subelements to be included when evaluating ownership costs is included in Life Cycle Cost in Navy Acquisitions. [Ref. 1] A detailed discussion of the life-cycle cost structures is beyond the scope of this research.

The general framework for determining the total cost of a system is applicable to both major systems and subsystems such as support equipment. Part of the decision process in selecting an item of automatic test equipment (ATE) is to conduct a life impact cost analysis (LICA). [Ref. 13:p. 1-11] "LICA is a modeling effort to determine the lifetime support costs of any ATE selection decision." [Ref. 13:p. F-1] The costs reviewed during a LICA are:

* Non-recurring and recurring acquisition,
* Non-recurring and recurring support equipment,

* 15-year support equipment operating and support (ILS), and

* Avionics related costs that are impacted by the selection. [Ref. 13:p. 1-11]

The cost of a system includes research and development, production, operating and support and disposal cost. Operating and support costs are usually the greatest share of the total cost. The ownership costs for ATE are reviewed during the life impact cost analysis and are to be considered when selecting a piece of support equipment to be developed.

C. COST ESTIMATING METHODOLOGIES

There are basically three approaches to estimating total life-cycle costs. They are the analogy, parametric and engineering methods of cost estimating. Each method has unique characteristics which may make it more suitable for one phase of the acquisition process as opposed to another. "The degree of product refinement determines the applicability of each technique." [Ref. 1:p. 42]

> In general, analogy and parametric are most useful during the early stages of a product's life, serving as an order-of-magnitude estimate of the potential costs. As the design stabilizes and more information becomes available, parametric cost estimating becomes a more useful technique. Later, when the detailed product design has occurred and specific tasking requirements can be levied, engineering estimates and the projection of actuals may become a more appropriate device for estimating cost. [Ref. 1:p. 42]

Analogy is a methodology which takes actual, historical cost data and applies adjustments for such things as: differences in technology, geography, configuration, specifications, operational environment, quantities and schedules

[Ref. 1:p. 42]. "This technique relates the cost of a current acquisition or alternative acquisition under consideration to that of similar previous acquisitions." [Ref. 1:p. 42] One of the difficulties inherent in the use of analogous estimating is the inability to assess the effect of changes in the technological sophistication of products. [Ref. 1: p. 43]

Parametric estimating uses cost estimating relationships (CERs) to determine the total cost of a system. CERs are mathematical relationships between some variable characteristic and the cost of a product. [Ref. 1:p. 43] This technique is not well-suited to the early phases of procurement and is best suited for the later stages of full-scale development.

> Parametric operating and support costing can be a viable technique during the later stages of the full scale development phase when the contractor has been able to collect preliminary data relevant to component failure rates, repair costs, and other logistics related parameters for engineering models or early operational models. [Ref. 1:p. 44]

Parametric estimating is dependent upon an accurate historical cost data base. The existing data bases and cost collection techniques are considered by many to be ineffective.

> Compounding this problem is the lack of an effective data collection process for accumulating and aggregating the historical O&S costs of major weapon systems. Elaborate techniques exist for collecting data on such sublevel items as part demand rates, maintenance actions, and other logistics factors, but these discrete methods support specific logistic management functions which do not provide an interactive data base for deriving CERs. [Ref. 1:p. 44]

The engineering estimate has little or no relevance during concept exploration and demonstration/validation [Ref. 1: p. 48]. It is however, a practical estimating tool for full-scale development. Like parametric estimating, engineering estimates are dependent on a historical data base. Engineering estimates are "bottom up" estimates which synthesize the detailed costs associated with each part of the acquisition. It is the most detailed way of estimating costs. [Ref. 1: p. 45]

Estimating future ownership costs has some built in uncertainties. To minimize the effect of these uncertainties specific information should be provided to the cost analyst.

> Any description of future events or circumstances is speculative and inherently uncertain; but to perform an LCC analysis, the product under investigation should have an adequate description of such aspects as design, manufacture, testing, training, delivery, deployment, operation, and support. [Ref. 1:p.47]

The three most common cost estimating techniques in use today are analogy, parametric and the engineering method of cost estimation. The degree of product refinement determines the applicability of each technique.

D. ORGANIZATIONAL STRUCTURE OF THE SUPPORT EQUIPMENT DIVISION

This section will provide a brief outline of the Support Equipment Division, of the Naval Air Systems Command and the procedures that are followed in determining the total cost of ownership of support equipment. The structural framework within which support equipment (SE) is managed is depicted in Figure 2-1. Air-310, Air-417, Air-552, Activity are specifically concerned with the design, development, production, management and deployment of support equipment. [Ref. 5:p 12] However, each of the functional areas is either directly or indirectly associated with support equipment.

The Support Equipment Division (Air-552) is divided into three branches according to the type of equipment being managed. The branches as shown in Figure 2-2 are: Weapon Systems and Acquisition Branch (Air-5521), Avionic Systems Support Equipment Branch (Air-5522) and the Propulsion Systems Support/Handling and Servicing Equipment Branch (Air-5523). Each branch has the responsibility for ". . . managing research, design, development, test, evaluation and modification" [Ref. 14:p. 5521-3] for their respective systems. Each branch is in turn subdivided as illustrated in Figure 2-3 for Air-5521, Figure 2-4 for Air-5522, and Figure 2-5 for Air-5523. The responsibilities of each branch include: budgeting, funding, design, development, test and evaluation, acquisition, and delivery of all support equipment under their cognizance.

The organizational structure for determining ownership costs for support equipment are not as clearly defined. In conducting this research the researcher was unable to determine the procedures for projecting the life-cycle cost of other than automatic test equipment (ATE).

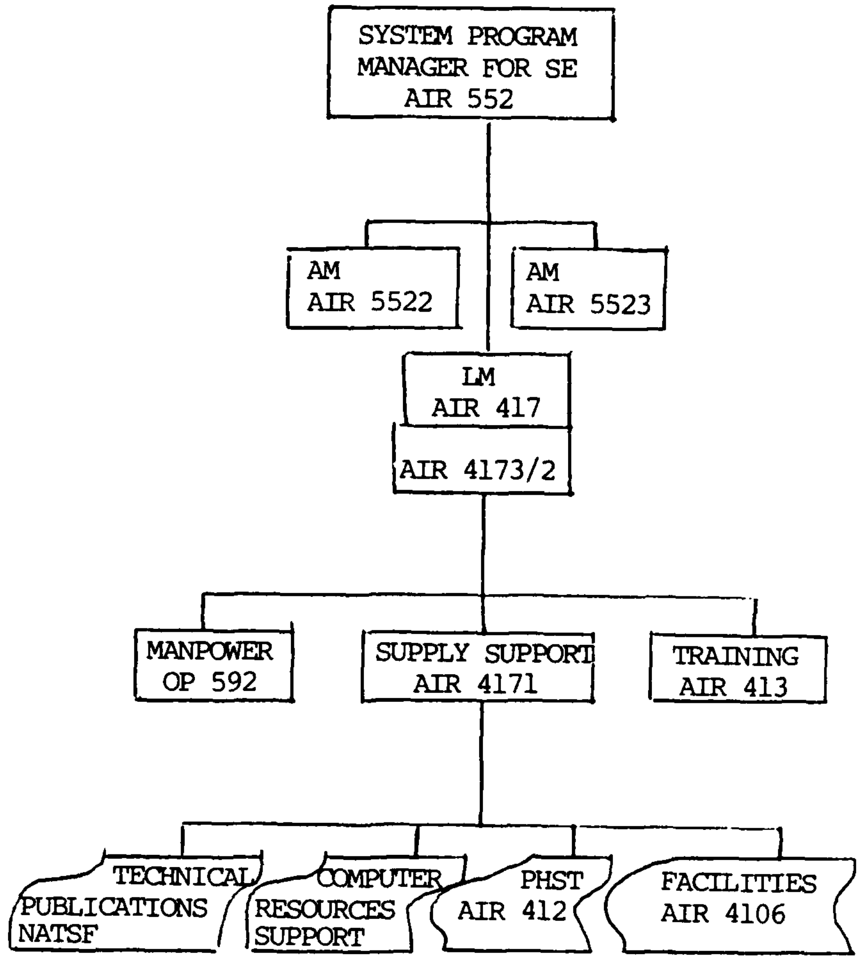


Figure 2-1. Support Equipment Acquisition Matrix
[Ref. 5:p. 22]

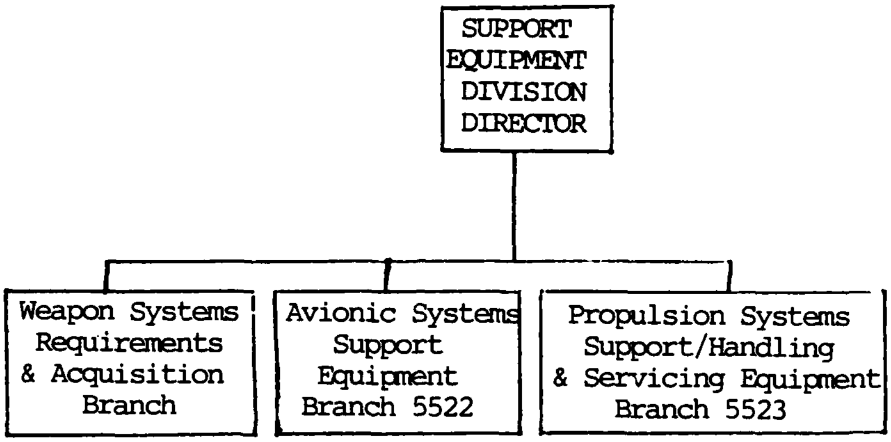


Figure 2-2. Support Equipment Division
[Ref. 14:p. 552-1]

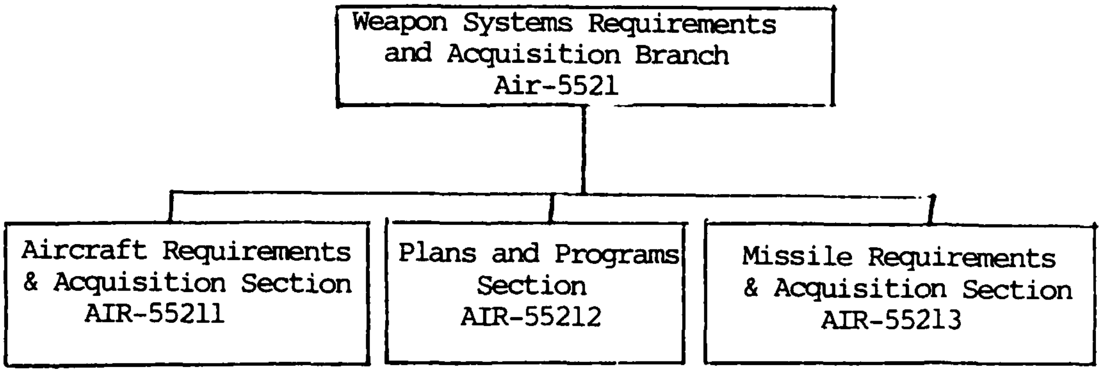


Figure 2-3. Weapons Systems and Acquisition Branch
[Ref. 14:p. 5521-1]

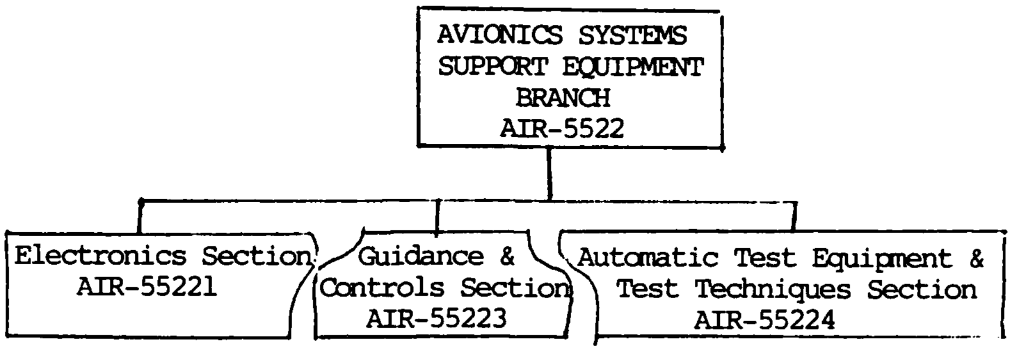


Figure 2-4. Avionics Systems Support Equipment Branch [Ref. 14:p. 5522-1]

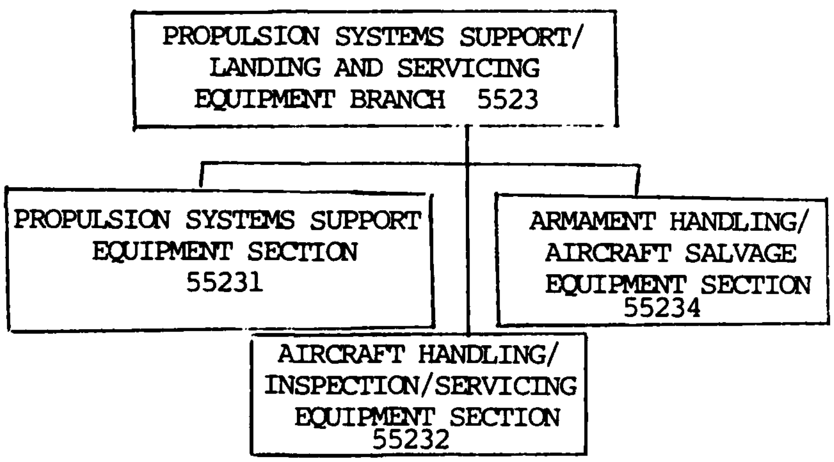


Figure 2-5. Propulsion Systems Support/Landing and Servicing Equipment Branch [Ref. 14:p. 5523-1]

The procurement process for SE is set in motion by the identification of a need for additional support equipment by either the fleet, NAVAIR Headquarters, a field support activity, or a contractor involved in weapon system development. [Ref. 5:p. 27] Regardless of whether the need is for peculiar or common SE, the requirement is documented by the submission of a support equipment requirement document (SERD). The SERD contains a technical description, drawings and cost information for the proposed item.

Determining the life-cylce cost of ATE is part of the support equipment selection analysis (SESA) and is defined in detail in the SE Selection Guide. The technical analysis, as well as the cost analysis, is performed by the Naval Air Engineering Center (NAEC) in Lakehurst, New Jersey. [Ref. 13:p. 1-12] According to the Guide, the SESA and the selection process should be completed soon after the prime system enters full-scale development (FSD). This has the advantage of permitting the modification of ATE and development of test program sets (TPSs) while the prime system continues through FSD. Completing the process early offers a higher probability that the prime and support systems will be ready to meet operational evaluation (OPEVAL) milestones. [Ref. 13:p. 1-5]

The selection process is divided into three phases or cycles: data collection, technical analysis, and cost and management analysis. The data collection phase is concerned with the gathering and analyzing of test requirements information and comparing it with existing ATE. The final product is a list of possible ATE candidates which possess the general capabilities required. The second phase is technical analysis and consists of an analysis of viable alternatives and results in selecting those items which are technically suitable. The final phase is cost and management analysis. At this time, the life-cycle cost of each alternative is developed and the inherent risks associated with each alternative are evaluated. [Ref. 13:pp. 2-1 to 2-5]

A detailed discussion of the support equipment selection process may be found in the SE Selection Guide [Ref. 13] and further information concerning the historical development of the Support Equipment Division may be found in Naval Aviation Support Equipment Acquisition Policies and Procedures In The 1980's [Ref. 5].

E. SUMMARY

This chapter has pointed out that total life-cycle costs exceed the procurement cost of a system by a wide margin with aviation support equipment accounting for as much as 10% to 50% of the cost of the prime equipment. Costs typically included are: research and development, acquisition and operating and support costs. Operating and support cost is generally the largest single element. The most common methods for estimating these costs are the analogy, parametric and engineering methodologies.

The life-cycle cost of aviation automatic test equipment is evaluated during the support equipment selection analysis. The actual cost estimating is performed by the Naval Air Engineering Center in Lakehurst, New Jersey.

III. PROGRAMS TO MANAGE THE TOTAL COST OF OWNERSHIP

A. INTRODUCTION

Historically there have been a wide range of programs and acquisition techniques employed to reduce the life-cycle cost of a system. This chapter briefly describes some of the methods which have been used. A discussion of the problems encountered with each approach is included in subsequent chapters. Before proceeding, it should be pointed out that no one single program, with the exception of Design-To-Cost (DTC) and competition, is intended to reduce each facet of total ownership cost. Rather, each program is directed at a particular segment of total cost. The program manager may choose to employ any or all of the techniques to be discussed.

B. DISCUSSION

1. Design-To-Cost

Design-to-cost (DTC) is an acquisition methodology which was implemented to place emphasis on life-cycle cost throughout the acquisition process. It provides a management framework within which to manage cost by; "Establishing cost as a parameter equal in importance to technical and supportability requirements and schedules." [Ref. 15:p. 1] Some of the techniques which could be used to achieve DTC goals are standardization, value engineering, preplanned-product improvement, warranties and competition.

2. Competition

Competition is another tool which may be used to reduce the total cost of ownership. Competition may be applied to major systems and components alike. Robert Seldon stated that maintaining competition as long as possible is a highly effective method of controlling life-cycle cost [Ref. 6:p. 256]. Competition may be employed to reduce total cost by including life-cycle cost as a source selection criteria. To win the contract, the contractor must consider the total cost of ownership in his proposal.

To facilitate competition at the replenishment part level, the DoD has been using a program referred to as BREAKOUT. A replenishment part is defined to mean parts, whether they are consumable or repairable, which are procurred after provisioning to support the end item. Examples of end items include aircraft, engines, electronic systems, ground support and test equipment. [Ref. 16:p. s6-104] BREAKOUT is a subset of the BOSS (Buy Our Spares Smart) program which seeks to identify those parts which may be competitively procured. This may entail competing the part when more than one source is available or buying direct from the actual manufacturer vice the prime contractor in a sole source environment. The objective is to:

> Reduce costs by "breakout" of parts for purchase from other than prime weapon system contractors while maintaining the

integrity of the systems and equipment in which the parts are to be used. [Ref. 16:p. 6-102]

Costs are reduced by competing parts which previously were purchased from the prime contractor in a sole source environment.

The general guidelines for BREAKOUT, as put forth by the DoD, are:

* Parts should be identified for breakout as early as possible,
* The preference is for breakout to competition,
* BREAKOUT improvement efforts shall continue throughout the life-cycle of the system,
* Priority should be given to those parts offering the greatest opportunity for breakout and potential savings, and
* Small and disadvantaged businesses should be given the opportunity to provide repair parts. [Ref. 16:p. 6-104]

3. <u>Pre-Planned Product Improvement</u>

Pre-Planned Product Improvement (P^3I) is an acquisition concept which makes it possible to "develop and field a new weapon system while improvements to that system are being planned for phased integration." [Ref. 17:p. 5-46] P^3I is an acquisition concept which programs resources to accomplish the orderly and cost effective phased growth of a system's capability, utility and operational readiness [Ref. 18:p. 18]. It is a proactive program in that it is planned evolutionary growth as opposed to product improvement and planned product improvement which are both reactive programs. The concept has as one of its main objectives, to reduce overall acquisition, operating and support costs [Ref. 18:p. 18]. One way in which this goal is achieved is by reducing the logistics support burdens caused by a dependency on "cutting-edge" technology. [Ref. 18:p. 21]

4. Value Engineering

Value engineering (VE) is a method of procuring materials representing the "best buy" in terms of the function to be performed [Ref. 20:p. 310]. "Value engineering is intended to be a primary mechanism for cost reduction during production and logistic support phases of the life of systems and equipment." [Ref. 8:p. 2-20] Cost savings are realized by identifying those parts or items which can perform the required function as efficiently and inexpensively as possible. [Ref. 20:p. 311]

The benefits of value engineering are recognized but there is some concern over whether or not the Navy is taking full advantage of them.

> The use of VE during engineering development to support the continuous review of systems and equipment against design to objectives for acquisition and ownership costs is potentially valuable in managing life cycle cost, but the present emphasis is on the contractual mechanism of the value engineering change proposal (VECP), a more specific application. There is reason for concern, too, over the level of VECP activity. [Ref. 8:p. 2-21]

Recognizing the economic advantages of a value engineering program and the current shortcomings of that program, Admiral Busey, Commander, Naval Air Systems Command, forwarded a letter to contractors stating that the Navy is serious about value engineering. The letter states that all VECPs will be reviewed and processed expeditiously. [Ref. 19]

5. Standardization

The lack of standardization is viewed as a major cost driver for electronics [Ref. 3:p. 1] "It can be seen that there is a complete lack of standardization-no standardization in the connectors, the frames, the size of the card, mechanical holding, etc." [Ref. 3:p. 1]

As defined in the Acquisition Strategy Guide, standardization is:

> The process by which the Department of Defense achieves the closest practicable cooperation among the Services and Defense agencies for the most efficient use of research, development, and production resources, and agrees to adopt on the broadest possible basis the use of:
> * Common or compatible operational, administrative, and logistic procedures,
> * Common or compatible technical procedures and criteria,
> * Common, compatible, or interchangeable supplies, components, weapons, or equipment, and
> * Common or compatible tactical doctrine with corresponding organizational compatibility. [Ref. 17:p. 5-54]

Cost savings are realized through standardization by reducing unnecessary proliferation, time savings, reducing risk by using parts with known performance histories and by enhancing competition by increasing the number of suppliers. [Ref. 17:p. 5-55] A disadvantage which should be pointed out is that the "overzealous application of standards may also restrict the incorporation of newer technology in the system or in processes used in producing the system." [Ref. 17:p. 5-55] Another disadvantage is that standardization may increase the life-cycle cost by reducing competition. Competition is reduced by limiting contract awards to previous manufacturers. [Ref. 19]

When one considers that there may be as many as 3000 items of peculiar support equipment (PSE) per weapon system [Ref. 21] the need for standardization becomes apparent. The Support Equipment Division of the Naval Air Systems Command has established a goal to maximize standardization. Towards this end:

> The contractor is required to use the Technical Information File and the Standard General Purpose Electronic Test Equipment File to identify support equipment currently in the inventory as possible end items to satisfy the identified requirements. [Ref. 5:p. 32]

A recent development pertaining to standardization is the implementation of Military Standard 2097(AS) dated 24 July 1985, which requires the contractor to certify that they have screened the existing inventory to identify existing test equipment which may be used.

6. Maintenance Philosophy

Two other methods being employed to reduce the total cost of aviation support equipment are by following a selection order of priority for automatic test equipment and by analyzing various maintenance plans. The nature of the decision concerning the maintenance philosophy is embodied in this quotation:

> The significant trade-off is the choice between placement of support equipment at the user level for fast repair and high visibility or placement at more remote locations, using fewer equipments with more skilled personnel, for cheaper repair but a lower availability due to the longer turnaround time. This trade-off is done during the level-of-repair analysis (LORA). [Ref. 6:p. 88]

NAVAIR's recognition of the high cost of support equipment and the desire to control such costs is reflected in the ATE selection order of priority. The priority as defined in a letter issued by the Commander, Naval Air Systems Command is:

> a. Use of existing ATE--unmodified,
> b. Use of existing ATE with minor modification,
> c. Use of existing ATE with major modification, and
> d. Development of new tester(s) to meet requirements.
>
> The development and procurement of new automatic test equipment beyond the family of testers currently defined, represent a proliferation of peculiar avionics support equipment that the family of testers approach is intended to preclude. As such, any authorization to design, develop and/or acquire new ATE not officially approved and part of the NAVAIR family of ATE will require Command approval. [Ref. 22:p. 2]

7. Built-In Test Equipment

Built-in test equipment has been put forth as one means of increasing operational availability; however, there are some who doubt the economic feasibility of such an approach. "Usually, cost trade-offs show that the increased acquisition costs of built-in test equipment must then be justified, if at all, on the basis of the improved availability of the item." [Ref. 6:p. 218]

8. Incentives and Awards

Contractor incentives and award fees, although slightly different, are both used to motivate the contractor to pay special attention to designated areas of concern. "Incentive contracts offer a means of motivating contractors to achieve more than minimal program objectives without excessive risk." [Ref. 17:p. 5-29] Emphasis may be placed on unit-production cost, schedule, performance, life-cycle cost, reliability, maintainability, or any area the program office desires to receive special attention. To be effective incentive fees must be large enough to provide sufficient motivation to the contractor. [Ref. 6:p. 134]

The cost savings are realized by the contractor improving in areas such as reliability, maintainability, and supportability. The process encourages communications between the contractor and the Government.

> Through the incentive contracting process, which includes Government/industry dialogue, more realistic objectives can emerge, leading to more realistic contractual commitments-a key element in any contract. [Ref. 17:p. 5-30]

"Incentives are the main thrust of warranties/guarantees, and reliability/maintainability are the characteristics typically addressed." [Ref. 17:p. 5-61] One type of warranty which has been employed to improve reliability and maintainability, ultimately reducing operating and support costs, is the reliability improvement warranty (RIW). The warranty places responsibility for total cost with the entity that can best control it, the contractor. [Ref. 23: p. 27]

The RIW is a fixed-price contractual incentive for improving operational reliability and maintainability. The economic incentive for the contractor is to enhance the reliability and maintainability of the product so as to minimize his repair costs. It requires the repair of failures of the equipment during use for a specified period of time, usually five years with the minimum being three years. [Ref. 6:p. 140]

9. Test and Evaluation

Another method for reducing life-cycle cost is by increasing reliability. Test and evaluation is one way to accomplish this.

> The Test Analyze and Fix (TAAF) approach is a testing philosophy associated with developmental testing of hardware to improve the reliability of systems and equipment. Such development testing emphasizes reliability growth by using an iterative test-redesign-retest process that identifies corrective action to improve equipment design and manufacturing processes. [Ref. 17:p. 5-58]

The technique creates cost savings by reducing the number of deficiencies which must be corrected after a system is fielded and minimizes the need to introduce improvements to obtain the original operational reliability objectives. [Ref. 17:p. 5-58] A significant drawback of TAAF is the increased requirements for time, money and personnel early in the development program. Required funding can be as much as 5 to 10 percent of the development program. [Ref. 17:p. 5-59]

TAAF has been successfully used on selected avionics and mechanical systems of the F-18 aircraft. "It is estimated that the TAAF testing added $100 million to the RDT&E program but will save the program many times that amount through lower operational support costs throughout it's life cycle." [Ref. 17:p. 5-61]

10. Integrated Logistics Support

Integrated Logistics Support (ILS) is a management effort directed at the largest portion of life-cycle cost:

the operating and support phase of the life of a system. ... the integrating framework within the program's con- ... techniques work to control life-cycle costs." [Ref. ... 4-1] It is defined as:

> . . . a unified approach to the management and technical activities necessary to: cause support considerations to influence requirements and design; define support requirements that are operationally related to the design and to each other; (procure) the required support; and provide the required support during the operational phase at minimum cost. [Ref. 24:p. 2-5]

C. SUMMARY

This chapter has presented some of the management methods which have been used to administer various elements making up the total cost of a system including: (1) design-to-cost, (2) competition, (3) pre-planned product improvement, (4) value engineering, (5) standardization, (6) maintenance philosophy, (7) built-in test equipment, (8) incentives and awards, (9) test and evaluation, and (10) integrated logistics support. Only two of the techniques described are directed at total cost: design-to-cost and competition. Integrated logistics support provides a framework within which to manage and reduce the costs incurred in operating and supporting a system. A total life-cycle cost management program is the framework within which a program manager works to control the total cost of a system.

IV. REGULATORY FRAMEWORK FOR THE MANAGEMENT OF LIFE-CYCLE COST

A. INTRODUCTION

This chapter discusses the Department of Defense and Navy Instructions and Directives which outline the policy towards managing LCC. The Directives also outline the framework within which Navy cost analysts operate in preparing and evaluating these estimates.

The basic policy of the DoD concerning major system acquisition is best described by an excerpt from the Military Handbook on Life-Cycle Cost in Navy Acquisitions.

> In an effort to maintain an effective, modern force in an acquisition environment constrained by finite resources and rising costs, an affordability acquisition policy has been adopted by DoD. The keystone of the affordability policy is an estimate of the total cost of a program or project over it's useful life, i.e., it's LCC. [Ref. 1: p. 8]

The Directives will be discussed in a sequence which parallels the procurement process. The first item to be discussed is OMB Circular A-109, Major System Acquisitions. It established the broad policies and objectives of Government procurement. DoDD 5000.1, Major System Acquisition, establishes the policies of A-109 as those of the Department of Defense. These policies are implemented by DoDD 5000.2, Major System Acquisition Procedures. The next Directive to be discussed outlines the emphasis to be placed on ownership costs during the source selection process. This is DoDD

4105.62, Selection of Contractual Sources for Major Defense Systems. This will be followed by the Directives on design-to-cost and integrated logistics support. DoDD 5000.3, Test and Evaluation, and DoDD 5000.4, OSD Cost Analysis Improvement Group, provide the framework within which to monitor progress and evaluate life-cycle cost estimates. The SE Selection Guide provides a detailed description of the procedures to be followed in selecting automatic test equipment (ATE).

It should be pointed out that while the items discussed are "directive" in nature for major systems, the policies, principles and objectives described therein are equally applicable to less than major systems, e.g., aviation support equipment.

B. DISCUSSION

1. Federal Procurement Policy

OMB Circular A-109 was issued on April 5, 1976 in response to the report of the Commission on Government Procurement which called for a disciplined acquisition process. The purpose of the Circular is to "establish policies to be followed by executive branch agencies in the acquisition of major systems". [Ref. 25:p. 1] The Circular sets forth the general policy, management objectives, and identifies the key decisions to be made in major systems acquisition. The four key decisions to be made are:

* Identification and definition of a specific mission need,

* Selection of competitive system designs to be advanced to a test/demonstration phase,

* Commitment of a system to full-scale development and limited production, and

* Commitment of a system to full production. [Ref. 25: p. 7]

The Circular focuses on the effectiveness of the management of major systems acquisition and emphasizes innovation and competition.

The importance to be placed on the total cost of a system is first brought out in the definitions of mission need and program objectives. As defined in A-109: ". . . mission need means a required capability within an agency's overall purpose, including cost and schedule considerations." [Ref. 25:p. 2] Program objectives are defined to mean: ". . . the capability, cost and schedule goals being sought by the system acquisition program in response to a mission need." [Ref. 25:p. 2] Each definition includes the word "cost", yet whether it refers to unit production cost (UPC), or total cost of ownership, is not specifically stated. Although not clearly defined, when taken in context with the entire Circular, it is the researcher's position that cost is referring to the total cost of ownership.

The policies of A-109 are designed to ". . . ensure the effectiveness and efficiency of the process of acquiring major systems." [Ref. 25:p. 3] The Circular calls for the expression of needs in mission terms vice equipment terms. Given that the definition of mission needs includes costs, this means that the total cost of ownership is to be considered when establishing needs. To accomplish this it is pointed out that competition should be pursued during the concept exploration phase to encourage the development of alternative system design concepts. [Ref. 25:p. 3] As will be pointed out in a subsequent chapter, early involvement is essential to the success of an LCC management effort.

The importance of life-cycle cost management is further emphasized in the acquisition objectives identified in the Circular. Specifically, an acquisition strategy should be tailored to each acquisition and the program manager should ensure that appropriate trade-offs are conducted between critical program elements, one of which is ownership costs. Additionally, to bring attention to cost management early in a program, benefits to be derived from trade-offs between technical performance, acquisition costs, ownership costs and schedule, should be considered during the source selection process. [Ref. 25:p. 9]

Because of it's importance, the next objective is quoted in it's entirety.

> Maintain a capability to: * Predict, review, assess, negotiate and monitor costs for system development, engineering, design, demonstration, test, production, operation and support (i.e., life-cycle costs). *Assess acquisition cost, schedule and performance experience against predictions, and provide such assessments for consideration by the agency head at key decision points. * Make new assessments where significant costs, schedule or performance variances occur. * Estimate life-cycle costs during system design, concept evaluation and selection, full-cale development, facility conversion, and

production, to ownership costs, schedules, and performance.
* Use independent cost estimates, where feasible, for comparison purposes. [Ref. 25:p. 5]

The important elements of this objective are that the Navy is to develop life-cycle cost estimates, use independent cost estimates for comparison purposes and monitor them during each stage of the procurement process. Noticeably absent is the lack of a requirement to assess LCC experience against predictions and the use of such assessments at key decision points. The objective only calls for the analysis of acquisition cost, schedule and performance.

To briefly summarize, OMB Circular A-109 states that it is the policy of the Government to procure effective, affordable systems. Affordable is further explained to be an appropriate balance between technical performance, acquisition costs, ownership costs, and time to develop and procure a system.

2. Department of Defense Acquisition Policy for Major Systems

DoDD 5000.1, Major System Acquisition, is the Department of Defense statement of policy for the acquisition of major systems. The Directive implements OMB Circular A-109 and is the governing directive for the acquisition of major systems except when statuatory requirements override. Although focused on major systems acquisitions, the principles and objectives are equally applicable to less than major systems. [Ref. 26:p. 2] This can be interpretted to mean that the same emphasis being placed on cost and supportability for major systems should also be placed on support equipment.

The concern for supportability is a primary issue throughout the Directive. It calls for the consideration of logistic supportability early in the formulation of the acquisition strategy and in its implementation. To accomplish one of the primary objectives of the acquisition process, which is improved readiness and sustainability, equal emphasis should be placed on resources required to enhance supportability, performance and schedule. [Ref. 26:p. 2]

System affordability is heavily emphasized. "Affordability, which is a function of cost, priority, and availability of fiscal and manpower resources, shall be considered at every milestone and during the PPBS process." [Ref. 26:p. 6] Cost was not specifically defined in A-109 nor is it defined here. When the Directive is read as a whole it can be concluded that cost means the total cost of ownership as opposed to unit-production cost (UPC). To procure an affordable weapon system a balance should be sought between acquisition cost, ownership cost, schedule and performance. [Ref. 26:p. 3] Although ownership cost is emphasized it should not be construed that cost is to be the overriding factor. To facilitate meaningful trade-off studies, life-cycle cost estimates must be realistic, realistically budgeted and the effort realistically funded. [Ref. 26:p. 2]

3. <u>Major System Acquisition Procedures</u>

DoDi 5000.2, Major System Acquisition Procedures, implements DoDD 5000.1. The Instruction spells out the procedures to be followed, and the documentation to be submitted, to attain the objectives listed in DoDD 5000.1.

Life-cycle cost receives early attention in the life of a major system in that it is part of the documentation required for a Justification for Major System New Start (JMSNS). When a concept has been selected the procurring office is required to submit gross estimates of the projected life-cycle cost. [Ref. 27:p. 3-1]

A major system acquisition will normally be subjected to two reviews by the Defense Systems Acquisition Review Council (DSARC). Life-cycle cost will be considered at each of these reviews. The first review is conducted at Milestone I and serves as the basis for approval to proceed from concept exploration (CE) to the demonstration and validation phase (DEMVAL). Documentation for the review is provided in the form of a System Concept Paper (SCP).

> The SCP is used to summarize the results of the concept exploration phase up to Milestone I, to describe the DoD Components acquisition strategy, including identification of concepts to be carried into the demonstration and validation phase, and reasons for elimination of other concepts; and to establish goal thresholds, and threshold ranges (as appropriate) to be met and reviewed at the next milestone. [Ref. 27:p. 4]

The second major review is at Milestone II and serves as the basis for approval to move from DEMVAL to full-scale development (FSD). Documentation for Milestone II is provided in the form of a Decision Coordinating Paper/ Integrated Program Summary (DCP/IPS).

> The DCP/IPS consists of two documents that provide different levels of detail for consideration by the DSARC. The DCP is a top-level summary document that identifies alternatives, goals, thresholds, and threshold ranges, as appropriate. The IPS will provide more specific information on the program and shall be prepared when the DAE determines that the DCP lacks information on which to base the requisite decision. [Ref. 27:p. 4]

The same format is used for both the SCP and the DCP. LCC requirements are clearly indicated in the annexes to the basic format. The annexes are:

* Annex A: Example of Program Structure.
* Annex B: Thresholds.
* Annex C: Resources-Cost Track Summary.
* Annex D: Resources-Funding Profile.
* Annex E: Summary of Life-Cycle Cost of Alternatives.

The Cost Track Summary requires cost estimates for the total operating and support phase, the average annual system O&S costs, and the total life-cycle requirements. The Funding Profile also calls for an estimate of total life-cycle requirements and Annex E contains a summary of life-cycle cost alternatives. As the title implies, the Annex contains a list of alternatives and the total cost of ownership for each. Annex B lists the thresholds to be achieved by Milestones II and III. The cost thresholds listed are: RDT&E (total), procurement (total), flyaway (unit) and procurement (unit). Absent from the cost thresholds is life-cycle cost.

4. Source Selection, Policies and Procedures

From a life-cycle cost management perspective, this Directive details the emphasis which should be placed on the total cost of a system during the source selection process. As is the case with DoDD 5000.1, the provisions of this Directive are also applicable to less than major systems, i.e., support equipment. [Ref. 28:p. 1] The attention that should be afforded cost is dependent on the specified relative order of importance assigned to cost in the solicitation, which should be detailed in the evaluation criteria to be used.

> When cost is weighted in development source selections, the specified relative order of importance is intended to provide general guidance to offerors on the relative importance that the Government attaches to cost considerations, including unit production cost and life cycle cost objectives. Such guidance is intended to be used by offerors to include affordability considerations when making tradeoffs to achieve a balanced proposal that is responsive to mission requirements while also reflecting program constraints. [Ref. 28:p. 5]

The Directive recognizes the use of draft RFPs as a valuable source of information from prospective contractors and encourages their use. Information which may be derived from draft RFPs includes the identification of cost drivers, noncost-effective contract requirements and the identification of any other changes that would enhance the acquisition program by improving system performance or by reducing life-cycle costs. [Ref. 28:p. 7]

Independent cost estimates should be utilized in determining the cost realism of proposals submitted and to serve as a benchmark for comparative purposes. "The realism of the offeror's proposal should be indicated by a ranking relative to the Government's estimate." [Ref. 28:p. 8]

In summary, the Directive identifies the many variables that should be considered during the source selection process. To facilitate obtaining program objectives, a well-formatted acquisition strategy should be developed prior to the initial solicitation. In evaluating cost proposals independent Government estimates should be used to determine cost realism. The use of draft RFPs is identified as a potentially beneficial tool and, finally; cost proposals are evaluated from the standpoint of total cost to the Government as well as reasonableness and realism of the cost estimate.

5. Design-To-Cost

The purpose of this Directive is to ". . . update policies, responsibilities, and procedures for the application of design-to-cost (DTC) principles throughout the acquisition of defense systems, subsystems, and equipment." [Ref. 15:p. 1] Again, the Directive is applicable to all major systems and less than major systems as determined by the DoD Component [Ref. 15:p. 5]. The researcher views this Directive as critical to a life-cycle management effort and many of its provisions will be quoted in their entirety.

Before discussing the provisions of the Directive, it is necessary to point out the differences between goals, objectives, parameters, targets and thresholds. A goal is a firm cost or value which should be attained as opposed to an objective which is a tentative value and is subject to revision. DTC parameters are approved, measurable values to be used as design considerations and management objectives for subsequent life-cycle phases. Parameters are further subdivided into DTC targets. A threshold is a cost or value which if exceeded will cause a program review. [Ref. 15:p. 2-1]

The distinction between a goal and a parameter is important. As just mentioned, a goal is a cost or value that should be attained and, along with thresholds, must be included in the Secretary of Defense Decision Memorandum (SDDM) for approval. [Ref. 15:p. 3] Parameters, on the other hand, are approved, measurable values used as design considerations and management objectives for subsequent life-cycle phases and do not require approval of higher authority.

The design-to-cost policy of the DoD is to:

* Establish cost as a parameter equal in importance to technical and supportability requirements and schedules.
* Establish credible acquisition and operating and support (O&S) DTC parameters that are consistent with program plans and budgets and that achieve the best balance among cost, schedule, performance, reliability, and supportability characteristics.
* Require that cost considerations be addressed throughout the design, development, production, and deployment of defense systems, subsystems, and equipment.
* Ensure prompt cost feedback to engineers and managers to enable effective and timely cost reduction actions.

[Ref. 15:pp. 1-2]

The Directive calls for the early identification of cost and performance trade-offs to achieve a proper balance between acquisition and O&S costs. Some of the cost reducing techniques which may be employed are: value engineering, alternative operations and maintenance concepts, increased use of standardized and commercial equipment, producibility analysis, and industrial modernization incentives.

DTC objectives are required to be established during concept exploration. "As system definition continues the objectives shall become DTC goals or thesholds, and the system shall be designed to achieve these parameters." [Ref. 15:p. 2] Specifically, an acquisition DTC goal in the form of average unit flyaway (rollaway or sailaway) cost shall be established and DTC parameters for O&S costs such as manpower and maintenance requirements shall be established. [Ref. 15:p. 3] Nowhere in the Directive does it call for the establishment of O&S goals or thresholds.

The DTC goals and thresholds shall be identified and realistic and DTC targets shall be included in prime contracts. [Ref. 15:p. 4] Furthermore:

> Program managers shall identify high-risk or high-cost components, which are the major life cycle cost drivers that provide the greatest opportunity for design trade-offs. During contract performance, containing "cost driver" costs shall be emphasized. [Ref. 15:p. 4]

To motivate the contractor to earnestly manage cost, contractual incentives will be used ". . . to provide a financial reward to contractors after a demonstration that actual costs or other measureable factors are at or below stated DTC goals." [Ref. 15:p. 4] If a contractor's performance is to be evaluated progress towards achieving goals must be monitored. The Directive specifically calls for the tracking of all DTC parameters until they have been met.

6. <u>Policy for the Acquisition and Management of Integrated Logistic Suport Systems and Equipment</u>

Integrated logistics support (ILS) is an integral part of the acquisition process and provides the framework within which operating and support costs, a major portion of life-cycle cost, are controlled. This Directive establishes the requirement for life-cycle management of major system ILS and provides guidance for establishing ILS policy for less than major systems and equipment. [Ref. 14:p. 1] The policy of the DoD is to:

> . . . ensure that resources to achieve readiness receive the same emphasis as those required to achieve schedule and performance objectives . . . . These resources shall include those necessary to design desirable support characteristics into systems and equipment as well as those to plan, develop, acquire, and evaluate the support. [Ref. 14:p. 2]

To achieve the objectives of ILS, which is "to achieve system readiness at an affordable life-cycle cost", [Ref. 14:p. 2] provisions for an ILS program which begins at program initiation and continues throughout the life of the system, shall be included in the acquisition strategy. The program shall focus on designing in desirable support characteristics, manpower, personel and training requirements, evaluation of alternative support concepts and; "The early establishment of system readiness and supportability thresholds for verification or assessment during test and evaluation (T&E) before decision milestones." [Ref. 14:p. 2]

The availability of operating and support cost data is recognized as being an important element in conducting design trade-offs. The Directive requires that such information will be maintained and incorporated into the Visibility and Management of Operating and Support Cost (VAMOSC) data collection system. The information is also to be made available to developers of new systems at the level of detail needed to support design trade-offs. [Ref. 14:p. 4]

Briefly, DoDD 5000.39, calls for the establishment and funding of an ILS effort at the onset of a program. Emphasis shall be placed on designing in supportability, enabling a system to be fielded which will meet the operational requirements at the lowest total cost. Technical and cost data will be collected throughout the life of the system to be used for comparative purposes when fielding new systems.

7. Test and Evaluation

DoDD 5000.3, Test and Evaluation, details the policy for the conduct of test and evaluation by the Military Departments in the acquisition of defense systems. Those factors which will directly affect LCC are evaluated during Operational Test and Evaluation (OT&E). OT&E is that test and evaluation conducted to estimate a system's operational effectiveness and operational suitability, and will be conducted in as realistic and operational environment as possible. [Ref. 29:p. 3]

Initial Operational Test and Evaluation (IOT&E) is conducted prior to Program Milestone III and is generally keyed to a decision point in each of the major acquisition phases. During concept exploration, OT&E is conducted to evaluate competing technical approaches and to assist in selecting alternative systems concepts. During demonstration and validation (DEMVAL), OT&E will be conducted in as realistic an environment as possible to provide information relative to projected operational effectiveness and suitability of the candidate systems. OT&E is conducted during full-scale engineering development to provide a valid estimate of operational effectiveness and suitability. [Ref. 29: p. 4]

Initial Operation Test and evaluation provides the program manager with an additional tool to assess progress towards achieving assigned cost goals and thresholds.

8. The Cost Analysis Improvement Group

DoDD 5000.4, OSD Cost Analysis Improvement Group (CAIG), sets forth the policies and procedures to be followed by the CAIG. The CAIG is the principal advisory body to the DSARC on matters related to cost. Their primary duties are to review and evaluate cost estimates submitted by program offices, identify efforts needed to improve the technical capability of DoD to make cost estimates, and perform an independent analysis of each alternative and provide a projection of all elements of LCC to include: R&D, investment and O&S. [Ref. 30:p. 2]

9. The Suport Equipment Selection Guide

The SE (Support Equipment) Selection Guide details the procedures to be followed in the selection of Automatic Test Equipment (ATE). The Selection Guide is applicable only to avionic systems and not to propulsion systems, support and handling equipment or weapon systems.

The necessity to make the optimum use of available resources is given early attention as is the need to identify support equipment requirements early in the prime system development cycle.

> It is the policy of the Department of the Navy to manage ATE development, acquisition and utilization to ensure the cost effective mix of resources for each level of maintenance activity. Determination of the optimum mix requires comprehensive analysis within the context of overall U.S. Navy requirements, as opposed to system or platform-unique requirements. In addition, solutions to support requirements must be reached as early as practicable in the prime system development cycle, to ensure the timely acquisition and operation of ATE to support those systems. [Ref. 13:p. iii]

The manual outlines the procedures to be followed during the Support Equipment Selection Process (SESA). The SESA is divided into three phases: data collection, technical analysis and cost and management analysis. [Ref. 13:p. 1-2] The cost and management analysis is further divided into a Life Impact Cost Analysis (LICA) phase and a Program and Risk Evaluation (PRE) phase. It is during the LICA that LCC estimates are developed.

LICA is a modeling effort to determine the lifetime support costs of any ATE selection decision. It involves the identification and quantification of all cost impacts associated with each SE alternative under consideration. Cost is broken down into three categories: non-recurring costs for development, recurring costs for production, and operating and support costs. The analysis includes all the expenses anticipated for each alternative that will be incurred by implementing that alternative. [Ref. 13:p. 2-65] The manual also provides a detailed outline of the Cost Element Breakdown Structure (CEBS) for each of the three cost categories.

It is pointed out that LCC estimates developed during the analysis are just estimates and not fixed costs. It is further stated that the ". . . estimates should be revised as often as necessary in order to maintain the LICA as a valuable tool." [Ref. 13:p. 2-65] As will be pointed out later, LCC estimates for both major systems and support equipment are not updated as the system progresses through the acquisition process.

Finally, the importance given to the LICA report is characterized by this statement: "The LICA report is likely to achieve greater visibility than the other technical reports due to greater emphasis on life-cycle cost as a management tool." [Ref. 13:p. 2-81]

The SE Selection Guide details the procedures that should be followed in selecting automatic test equipment. Part of the process is an analysis of the life-cycle cost of alternative solutions which is conducted during the LICA. Application of the process is limited to ATE.

C. SUMMARY

This chapter has provided an introduction to the regulatory framework within which the total cost of ownership of a system is established and tracked. There are many common elements to these Directives, some of which are:

* The policies and procedures for managing life-cycle costs are equally applicable to major and less than major systems,
* Total cost shall be afforded the same status given to unit production cost, schedule and performance,
* Trade-off studies shall be conducted to achieve a balance between investment costs, ownership costs, schedules, and performance characteristics,
* Logistics supportability shall be given early management attention,
* Independent life-cycle cost estimates shall be developed and tracked, and
* A cost data base shall be maintained for feedback purposes.

The intent of all the Directives is to establish guidelines to enable the services to procure affective and affordable weapon systems.

V. INDUSTRY PERSPECTIVE REGARDING THE PROBLEMS AND ISSUES OF MANAGING LIFE-CYCLE COST

A. INTRODUCTION

This chapter will explore the obstacles to managing life-cycle cost (LCC) which have been identified by this research in the literature and through interviews with contractors for aviation support equipment.

After reviewing the literature and conducting several interviews, the researcher has grouped the obstacles confronting industry in the below listed categories. The grouping will facilitate a discussion of the problems and the identification of recommended solutions.

* Optimistic LCC estimates
* Government/industry interface
* Requests for proposals
* Lack of commitment
* Early commitment
* Communications between the end user and industry
* LCC goals and measurements
* Data base
* Aviation Support Equipment

B. DISCUSSION

1. Optimistic LCC Estimates

The procurement system encourages submission of optimistic LCC estimates. Harvey J. Gordon, former Deputy for

Acquisition, in the Office of the Assistant Secretary of the Air Force, recognized this and cited the program manager's desire to obtain program approval as the reason. "Both the military and industry tend to be optimistic in formulating estimates to serve as a basis for authorization and approval." [Ref. 31:p. 33] M. Robert Seldon, in his book entitled Life Cycle Costing: A Better Method of Government Procurement, points out: "If the estimators understand that their figures are to be the basis for future budgets, they are likely to inflate their estimates to provide a cushion for future problems." [Ref. 6:p. 30] This padding of the estimates obscures the true cost of a system.

Just as Navy PMs use optimistic estimates to win program approval, contractors use optimistic estimates to win the award of a contract. The Navy Program Manager's Guide points out that in a competitive environment, the ocntractor will tend to be over optimistic in the areas of cost, schedule and technical accomplishment in an effort to win the award.

> At the outset of a program, our DoD bid process encourages substantial contractor over optimism in technical accomplishment, in schedule, and in cost. The contractor environment is one of competition to win the support of the evaluators of the proposal; thus the contractor very much caters to the evaluator's interests. [Ref. 32:p. 4-35]

The point being made is that even when cost estimators have sufficient information from which to develop estimates, the figures submitted are intentionally optimistic. This is viewed by the researcher as detracting from the overall effectiveness of an LCC management effort. The foundation of any life-cycle cost program is an estimate of total program cost and as such those estimates should be as accurate as possible. [Ref. 10:p. 377]

When used to support budget submissions, optimistic estimates have the potential of creating the appearance of cost overruns which threaten the existence of a program and detract from the credibility of the estimates. Use of estimates which are not realistic negates the effectiveness of an LCC management effort by establishing a baseline figure which is not truly representative of current and projected conditions. Finally, expenditure of already scarce resources to support the development of a cost figure which is not realistic and factually supportable is a waste of those resources.

Related to the issue of obtaining realistic estimates is the periodicity for submitting updates. While interviewing Mr. Daniel Frank, the ILS Manager for advanced requirements for Litton Guidance and Control Systems, it was pointed out that provisions for updating LCC estimates are presently included in contracts containing LCC clauses with some updates being required as frequently as quarterly. [Ref. 33] Mr. Frank also pointed out that due to the nature of the estimates, they are not subject to rapid changes and should be required no more frequently than semi-annually and, when possible should be timed to support DSARC milestones.

Requesting only essential updates is viewed by the researcher as one means of reducing costs.

2. Government/Industry Interface

There is a general lack of communications concerning LCC between industry and the Navy. During one interview, this interface was characterized as non-existent [Ref. 33]. During this same interview it was pointed out that the company was not aware of how the Naval Air Systems Command (NAVAIR) was organized to handle or develop LCC estimates, it was not known how the estimates were used and his company had received no feedback concerning the estimates or updates submitted. Another source characterized the relationship between many Government and company managers as having grown adversarial rather than open and cooperative [Ref. 8:p. 1-13]. The concern voiced by industry is shared by the Navy. As one Navy ILS manager put it: "Too much emphasis is being placed on strategy and not enough emphasis on the close working relationship between the Government and contract people." [Ref. 11]

A strong Government/industry interface is essential not only to the LCC management effort but to the success of the program as a whole. Mr. O. C. Boileau, President of Boeing Aerospace Company in Seattle, stated: "If design-to-life-cycle-cost programs are going to be successful, industry and government will have to become full partners." [Ref. 34:p. 9] The importance of the interface to the success of a program is further emphasized in this excerpt from the literature:

> Success in acquiring products with low overall cost of ownership would seem to depend on the ability of both Government and company managers to work together in handling the uncertain business of new product development. [Ref. 8:p. 1-13]

Both parties must understand each other's needs and there should be a free exchange of information. A close working relationship not only makes it easier to solve immediate problems but it also opens the channels for suggestions to improve the process.

A close working relationship between industry and the Navy before an RFP is released can help clarify vague or non-existent requirements and ensure that the data needed to develop an LCC estimate are available. Resolving any problems or confusion before a contract is signed saves both time and money and enhances the potential for a successful program. Speaking as a panel member at the 1984 Acquisition Strategy Workshop, Dr. A. Gates of Ford Aerospace, noted that the lack of communications, which he characterized as a lack of access to requirements documents, limits the ability of industry to fully understand what is required, thereby reducing overall technology innovation across the industry. [Ref. 35:p. 3]

A review of the literature will show that the technology in the avionics industry advances rapidly. In this regard there is a degree of uncertainty which must be factored into the acquisition strategy for a new system or component. In a published paper, Richard P. White of the Logistics Management Institute, recognized the dynamic nature of contracting in an uncertain environment and the need for flexibility by both parties.

> In this regard, acquisition under uncertainty is, by definition, a dynamic affair--problems emerge in both anticipated and unanticipated shapes. This environment does not sustain the usefulness of standard operating procedures very often or very long, nor is it subject to control by the most carefully planned contractual nostrums. [Ref. 8:p. 1-13]

Mr. Frank, although critical of the present state of the Government/industry interface was quick to point out it's advantages. [Ref. 33] He indicated that well-established lines of communications provide the means for identifying and fully understanding LCC requirements before an RFP is released. Feedback from the Navy enables industry to better understand exactly what the Navy wants in the way of cost estimaes. Industry feedback to the Navy can help identify and resolve problems the Navy has with it's LCC models.

3. <u>Requests for Proposals</u>

The RFP is one of the first instances of formal communication between the Navy and industry and is used to convey the information needed to develop LCC estimates and plans to the contractor. As such, it sets the stage for the future course of events. The literature supports the claim that attitudes and priorities gleaned from the RFP will be reflected in how the contractor responds. Recognizing this, the failure to include LCC goals and requirements can only harm any future LCC management efforts. Interviews with Navy ILS managers, representatives of the aerospace industry, and the literature, all characterize RFPs as being vague with regard to LCC. RFPs are generally characterized as lacking definition, information essential to the development of LCC estimates is insufficient and LCC goals and requirements are not included [Ref. 33]. Mr. A. M. Frayer, a staff assistant in the Office of the Assistant Secretary of Defense (I&L) in 1976, commented that LCC goals and requirements should be specifically stated in RFPs and statements of work [Ref. 7:p. 39].

The lack of adequate program information is detrimental to both parties of the contract. Industry needs reliable information to develop realistic estimates and the Navy needs good information to develop in-house estimates to use as a comparative baseline. Just as the needed information is considered to be lacking for industry it is also considered to be lacking for Navy ILS managers. Two Navy ILS managers stated that program offices do not provide the information necessary to prepare good estimates. The requirements are either not adequately stated or not provided at all [Ref. 11].

One interviewee stated that information essential for determining meaningful estimates of operating and support costs is lacking from RFPs. Operational scenarios, environmental data and employment information either do not contain sufficient information or are entirely lacking from RFPs. Aside from being able to develop meaningful cost estimates, the lack of such information leaves the adverse impression of insufficient front end planning on the part of the Government. [Ref. 33]

Insufficient program data will increase the cost of a program by increasing the risk to the contractor, particularly in the area of warranties. Forced to carry the risk of uncertainty, the contractor will compensate by placing a higher price tag on the warranty which ultimately translates into increased LCC.

> Contractors found that they were required to price warranties based upon specified reliability and maintainability levels with only limited development program data to predict their ultimate field reliability and warrant cost. [Ref. 36:p. 9]

The RFP is the formal document which will serve as the basis for a proposal that will ultimately result in the award of a contract. As one of the first pieces of formal correspondence in the acquisition process, it also sets the tone for future events. From discussions with industry and reviewing the literature, the researcher would conclude that:

* It is important that the Navy's intention to manage LCC be clearly stated in the RFP.

* LCC goals and requirements must be clearly defined, and

* The RFP must contain sufficient operational, environmental and deployment data to permit both Navy and industry cost estimators to develop realistic LCC estimates and management plans.

4. Lack of Commitment

It was previously stated that the attitudes and priorities expressed in the RFP set the tone for the future course of events. In a survey of military contractors conducted by C. David Weimer in 1979, it was shown that most military contractors are unconvinced of the Government's commitment to LCC and it's contractual ramifications [Ref. 6:p. 150]. A 1974 GAO report indicated that the DoD was placing less emphasis on the cost of ownership even though such costs could ultimately amount to more than acquisition costs. The report also points out that LCC have had limited application in decisions affecting major systems acquisitions due to uncertainty about the data used to develop estimates and the need for better cost models and estimating techniques. [Ref. 37:p. i]

Failure to include and properly emphasize the LCC management effort in the RFP is one of several contributing factors which have fostered the impression in both the Navy and industry that the Navy is not fully committed to managing life-cycle cost. The apparent lack of commitment is exemplified by both Navy and industry program managers who worry more about production cost than LCC, and by the fact that LCC efforts are readily sacrificed, if necessary, to remain within budget. Interviews with both Navy and industry ILS managers pointed out that little emphasis is placed on LCC during concept exploration and when DTLCC programs have been incorporated they have been included at the last minute and generally have not been well thought out. [Ref. 11]

The current emphasis being placed on design-to-unit-production-cost (DTUPC) vice life-cycle cost, is due to partly to a lack of understanding of the benefits to be derived from LCC management and the fact that program managers are evaluated based on the achievement of near term goals and not long term supportability. This conclusion is supported by a study conducted by LTC Caver of the Defense Systems Management College.

> A study done in 1979 showed that some 80 percent of the people responding to the survey believed that PMs and others in key decision-making positions in a system development tend to direct their attention to near-term acquisiton costs. Some 75 percent of those surveyed viewed unit-production cost as more important than life-cycle cost. [Ref. 35:p. 15]

Navy and industry ILS managers will point out that PMs are evaluated on present performance, not on how well the system can be supported or maintained in the future. [Ref. 33] This view was also expressed by Richard P. White in the following statement:

> It is also a matter of concern that the program manager may not be strongly motivated to authorize current expenditures to benefit later operating and support costs, particularly when present needs could claim all available funds. [Ref. 8:p. 2-25]

An Acquisition Improvement Working Group meeting in March 1981 suggested that reliability, maintainability, operational availability, and supportability be elevated to the same status as performance, schedule and unit production cost. [Ref. 38:p. 132] The researcher views this action as one means to increase the PM's commitment to LCC management.

Also contributing to the lack of commitment by both industry and Government PMs is a lack of understanding as to what can be accomplished in terms of cost savings through following an LCC management strategy. Their present knowledge as to how component parts interact is limited and there is little understanding of how unit costs affect other areas. [Ref. 33]

Saying no to higher reliability for reasons of cost does not in itself indicate a lack of commitment to life-cycle cost management provided that the decision was the result of a cost-benefit analysis. Mr. Andrew Cozzolino, a group engineer for Lockheed Support Equipment Engineering, brough out the point that: "Many times engineers are told no to higher reliability due to the cost involved and the desire to remain within budget." [Ref. 39] Political considerations which are difficult, if not impossible, to quantify may also be the overriding factor.

The literature is unanimous in claiming that an important element in a successful LCC management program is senior management participation. [Ref. 33] This applies to both industry and Government. If the senior management is not committed then there will be no interface and any LCC efforts will be ineffective.

Representatives from Litton, Teledyne and Lockheed all recognized the future impact of LCC management and, depending on the contractor, have already begun to develop and implement LCC management strategies. Mr. Frank commented that just as there must be commitment at high Government levels, corporate executives must also be fully committed to managing LCC. Increased emphasis is being placed on LCC when responding to RFPs, even when not specifically called for. He also expressed the view that the ability to accurately estimate LCC and incorporate them in proposals gave his company a competitive edge. [Ref. 33]

The emphasis on LCC management is increasing and industry is responding as evidenced by greater attention to LCC in the preparation of unsolicited warranty proposals. [Ref. 33]

5. <u>Early Commitment</u>

Increased commitment is important but to derive the full benefits of a successful LCC management effort, the commitment must come early and be sustained throughout the life of a program. Air Force Brigadier General J. W. Stansberry commented that to avoid unnecessary expenditures for support cost, life-cycle costing must be considered early in the system acquisition process. [Ref. 40:p. 19]

There is ample evidence in the literature to support the conclusion that LCC must be considered early in the acquisition process. Yet, each of the contractors interviewed cited the need for earlier emphasis on LCC. [Ref. 41]

The importance of early emphasis is highlighted by the fact that 80 percent of life-cycle costs are associated with the operating and support period of the life of a weapon system and 85-90 percent of the life-cycle costs are determined by the end of the demonstration/validation phase. [Ref. 35:p. 9]

Early commitment by the Government to an LCC management strategy provides the contractor the incentive to conduct design trade-off studies during the early life of a system when the greatest cost savings can be achieved. Dr. John J. Bennett states that: "The greatest payoff, of course, comes when supportability considerations are built in early in the design process so that design considerations can impact operating and support costs." [Ref. 42:p. 2] The Hardman Program Manager's LCC Handbook for Avionics Equipment states that to have an impact on design, cost analysis must be carried out very early in the acquisition cycle [Ref. 43:p. 2]. "For maximum impact, support concepts must be addressed during the conceptual phase of design when the basic approach to modularity and built-in testing and sensing should be decided, and the logistics approach derived from that point." [Ref. 43:p. 2]

Mr. O. C. Boileau pointed out that early emphasis on LCC is important because of the impact the designer has on the ultimate cost of a system.

> Because the designer has a lot of leverage on the ultimate cost of a product-affecting as much as 80 percent in some

cases-a research and development program must be given money and attention early. [Ref. 34:p. 7]

Early emphasis is important to make it clear to the contractor that it is the express intention of the Government to manage LCC. This fact is borne out by the observation that many contractors find late in the process that the procuring agency really intends to enforce the incentive provisions of a contract. [Ref. 6:p. 150] The researcher would conclude that although the Government has every legal right to enforce the incentive provisions of a contract, doing so late in the procurement process reduces any advantages which might have evolved.

Early emphasis on LCC is necessary to demonstrate to the contractor that the Government is committed to managing LCC and to allow logistics considerations to freely interact with and influence system design. The earlier in the life of a system that cost saving measures are incorporated, the greater the resulting cost savings will be. The Military Handbook for Life Cycle Cost in Navy Acquisition states: "To be effective, acquisition life-cycle costing begins in concept exploration and continues throughout the acquisition process." [Ref. 1:p. 9]

Industry recognizes that early consideration of LCC is important but it also realizes that it is very difficult to get design engineers, both Navy and industry, to consider LCC. To bring attention to the problem, Lockheed has undertaken an independent research and development effort to look at lessons learned during design to identify potential LCC problems to engineers early in the process. [Ref. 44]

To concern indicated by industry is also a concern of the Government.

> Our reliability and maintainability engineers don't fully understand the logistic process and before we can do a proper job of reliability by design we must understand the whole acquisition process including life-cycle considerations. [Ref. 35:p. 4]

6. <u>Communications Between the End User and Industry</u>

Communications between Navy program offices and industry is only half of the communications problem. The other hald if the interface between industry and the end user. Industry views open communications with the end user as vital to the success of a program, particularly in the area of support equipment, and views Government cutbacks in field visits as being detrimental to a successful LCC management program. [Ref. 44] The site or field visits can prove to be valuable to both industry and the Government for a number of reasons. Mr. A. T. Harcarik, Group Engineer, Support Equipment Engineering for Lockheed, pointed out two very important reasons that site visits are important. Visits make engineers more familiar with the fleet's requirements, and problems being experienced in the field can be discussed directly with the source. He also observed that the visits are beneficial to the Government in that they tend to make the user aware of the availability and proper application of support equipment.

Until a few years ago, the Logistics Engineering Department of Lockheed conducted site surveys for general support equipment. Some of the problems identified illustrate the importance of the visits and the potential for increased cost savings. The discrepancies listed on one survey are: [Ref. 44]

* The fleet was unfamiliar with new general support equipment (GSE).
* Fleet suggestions were slow in getting implemented.
* The fleet was unable to repair old GSE due to a lack of spares.
* Many GSE items were on the shelf and not being used because their application was not known.

The procurement of aviation support equipment is an expensive undertaking and to field equipment which is either improperly utilized, or not utilized at all, severely degrades the cost effectiveness of the SE program.

Mr. Frank pointed out that communications with the end user are useful in another aspect of LCC management. [Ref. 33] He states that the operational command or end user is an important element in the total LCC management effort in that they are the source of the data used to compute operating and support costs. Their biggest contribution to managing LCC is in providing reliable, factual data on a timely basis.

7. LCC Goals and Measurements

The lack of distinct, discretely defined LCC goals and measurements is viewed by industry as an obstacle which is preventing the Navy from deriving the full benefits of an LCC management program. A contractor for aviation support equipment pointed out that no LCC goals had ever been established for SE. [Ref. 33] A Navy ILS manager for the JVX program, which is currently between DSARC milestones I and II, stated that no official LCC targets had been established because at this point they could not be defined [Ref. 11]. The impact of LCC cost goals is further borne out by the following:

> Because it has not yet been possible to provide a contractual incentive for the entire LCC, the production cost goal (from DTC or DTUPC) are often the sole cost consideration in design. The contractor tries to decrease production costs, even if LCC suffers. [Ref. 6:p. 233]

When setting goals the Navy should define the content of the cost goal precisely and assure that all of its elements are controllable by the contractor [Ref. 6:p. 226]. Furthermore:

> Any contract that provides an LCC, RIW, or logistic support cost incentive must supply clear rules for measuring such costs, definitions of the performance expected, and a method of handling contingencies. [Ref. 6:p. 144]

A tracking, controlling and reporting procedure for the costs of the design helps to assure the achievement of cost goals and increases management's effectiveness in controlling costs.

> The effectiveness of controlling costs depends upon a knowledge of expected costs. Standards serve as measurements which call attention to cost variations. Executives and supervisors become cost-conscious as they become aware of results. This cost consciousness tends to reduce costs and encourage economies in all phases of business. [Ref. 45:p. 469]

In designing for LCC, the designer is governed by three primary variables; equipment specification, maintenance-use concept, and the LCC verification sampling plan. [Ref. 46:p. 31] The same reference brings up the fact that to gain a competitive edge, contractors closely examine the measurement techniques which may be used to their advantage.

> To win an LCC competition, the designer must attempt to assess the sensitivities of the overall LCC model and, as a subset of that consideration, particularly examine any peculiarities of the sample use plan that will be implemented to measure the apparent LCC. [Ref. 46:p. 31]

The researcher would conclude that to minimize "gaming" by contractors, the Navy should fully understand any goals it is imposing.

Specific problems which need to be addressed are [Ref. 33]:

* LCC goals and requirements have not been included in RFPs,

* LCC goals need to be near term, achievable and more realistic,

* The data elements needed to track performance need to be identified, and

* More reliable data collection techniques need to be devised.

From the Government side, Mr. Frayer recognized that to improve LCC management the requirements for performance, reliability, maintainability, availability, and cost should be correlated to be compatible. [Ref. 7:p. 39] He also commented that the work breakdown structure used for LCC should be correlated with cost and hardware breakdown structures.

8. Data Base

The Government lacks the appropriate data from which to develop LCC estimates and to analyze and track estimates provided by industry. A 1974 GAO report found that LCC has had limited application in decisions affecting major systems acquisitions. The report cited the uncertainty of the data used to develop estimates as a contributing factor. [Ref. 37:p. i] In 1976 a high Government official remarked that both Government and industry are short on historical life-cycle cost data [Ref. 7:p. 40]. The lack of an appropriate data base is still a problem today. As expressed by Larry Stahl, a Navy ILS manager:

> The state of the art in aircraft cost estimating is fairly well advanced when estimating the hardware costs. As for the operating and support related and other life-cycle costs, estimating is not very good at all because of poor data collection and poor data bases. [Ref. 11]

The lack of such a data base severely limits the Navy's efforts to manage LCC. Much of the data required for LCC management is developed during the Logistics Support Analysis (LSA) and the Level of Repair Analysis (LORA), however, the three are not tied together. The data elements need to be standardized and LCC models built to allow automatic data inputs. [Ref. 33]

An incomplete data base, although making things difficult, does not make managing LCC impossible. The Hardman Program Manager's LCC Handbook supports this claim by pointing out that there is a tremendous amount of data available in the minds of the engineers who will design the system even on the first day of a program. [Ref. 43:p. 3]

The literature supports the conclusion that most cost analysts believe that a reliable data base greatly enhances the validity of LCC estimates even in the early stages of procurement. [Ref. 37:p. 4] The same referenced GAO report claims that shortcomings in methods of data accumulation have hurt the credibility of LCC estimates.

9. <u>Aviation Support Equipment</u>

Some of the unique problems encountered in managing LCC for ASE, as identified by support equipment contractors, are [Ref. 44]:

* Delays in formalizing maintenance plans delay the submission of Support Equipment Requirements Documents (SERDs).

* There is a lack of communications between programs to identify SE being developed.

* Drawings in SERDs are not detailed enough to support competition.

* During SE design reviews DTUPC is emphasized, not DTLCC.

* There is no consistent application of contractual requirements for LCC management on SE.

SERDs are technical documents prepared by the contractor which identify the peculiar and common support equipment required to support a system. Present requirements state that SERDs do not have to be submitted until after the maintenance plan is formally approved. [Ref. 44] Mr. Ed Main, NAVAIR Support Equipment Logistics Management Division, observed that SERDs may be dropped at any time--even one month before the initial operating capability (IOC). This creates problems for the contracting officer who is trying to procure the system and the SPM-SE who is attempting to manage LCC. SERDs are rarely submitted before full-scale development. [Ref. 46]

It is important to consider support equipment requirements early in the procurement process to avoid delays in fielding the weapon system. This enables support requirements to interact with the engineering design thus minimizing the PSE and total SE requirements. The importance of early identification is recognized by the NAVAIR Support Equipment Division, and is expressed in the foreword to the SE Selection Guide.

> In addition, solutions to support requirements must be reached as early as practicable in the prime system development cycle, to ensure the timely acquisition and operation of ATE to support those systems. [Ref. 13:p. iii]

DODD 5000.39 requires that support requirements will interact with design. The effectiveness of this desired interaction is minimized when maintenance plans are not formalized until late in the program, long after the concept exploration phase has been completed. The problems arising from the late indentification of SE all tend to increase the potential of reducing the operational availability of a system through a lack of SE once it is fielded. The failure to identify SE gives rise to several potential problems. As discussed during interviews they are:

* In order to meet the IOC and avoid schedule delays, PSE must be purchased directly from the prime contractor.

* Due to limited time, the contracting officer frequently can not allow the market forces of competition to work, and is forced into a sole source position.

* Any cost savings which may have been derived from design tradeoffs during CE are eliminated. Once the design is frozen, it is extremely difficult and expensive to change it. [Ref. 46]

The lack of communications between programs concerning the development of SE creates the potential for funding multiple development efforts for the same or similar piece of SE. Although the Technical Information File, MILHNDBK 300, shows the applicability of support equipment to other programs, it is not considered by industry engineers to be current. [Ref. 44] Recognizing this, the FY85 Joint Logistics Committee on the standardization of ASE, undertook the task of updating the file. The task has since been completed. [Ref. 19]

Competition is a very strong force, which when properly used, can reduce the cost of a system. Efforts to complete SE are hindered by the fact the SERDs are not detailed enough to support competition. [Ref. 44] More detailed drawings will cost more and consequently, before considering such an alternative, a cost benefit analysis should be conducted to determine which approach will have the greatest favorable impact on LCC.

The problem of emphasizing DTUPC during SE design reviews as opposed to DTLCC was discussed earlier in this section. The inconsistent application of contractual requirements for LCC management on SE was also previously discussed.

C. SUMMARY

Life-cycle cost estimates developed by both the Navy and industry tend to be over optimistic. Navy PMs are prone to be optimistic in their estimates to win program approval. If the estimates will serve as budget inputs, the tendency is to inflate them to provide a cushion for future contingencies. Contractors on the other hand, will be optimistic with their estimates in an effort to win the contract. Use of less than realistic cost estimates has the potential of harming a program by creating the appearance of cost overruns. Use of estimates which are not realistic degrades the benefits to be derived from an LCC management effort by establishing a less than accurate baseline.

A well-structured RFP can be very beneficial to managing LCC. Not only does the RFP provide the information to develop estimates, but it also highlights those areas which will be emphasized by the Navy. The problem arises from the fact that the operational scenarios, environmental data and employment information needed to develop LCC estimates are generally lacking from RFPs. As one of the first pieces of formal correspondence with the contractor, the RFP sets the tone for the entire project.

The research shows that most contractors are of the opinion that the Government is not fully committed to managing LCC. This is evidenced by a failure to include and properly emphasize the LCC management effort in the RFP, the fact that PMs are evaluated based on the achievement of near term goals and not long term supportability, and a lack of understanding of the benefits to be derived from LCC management. It has been suggested that to increase the emphasis on LCC, reliability, maintainability, operational availability, and supportability should be elevated to the same status as performance, schedule and UPC.

Placing an early emphasis on LCC is important not only to demonstrate to the contractor the Navy's commitment, but also to derive the greatest economic benefit. The design engineer plays a vital role in determining the ultimate LCC of a system. Eighty five to ninety percent of the life-cycle costs are determined by the demonstration/validation phase.

From an industry perspective, it is not only important to have a strong interface with the buying office, but with the end user as well. This interface is viewed as particularly important for support equipment. Site or field visits are beneficial to both the contractor and the Navy. For the contractor, the visits enable engineers to become more familiar with the fleet's requirements and bring them closer to the source of problems. The Navy benefits by having the contractor demonstrate the proper application of support equipment.

The end user is the ultimate source for data pertaining to operating and support costs. Their biggest contribution to the LCC management effort is in providing reliable, factual data on a timely basis.

The inclusion of LCC goals and thresholds in major systems contracts have been sporadic, and non-existent for ASE. LCC goals and thresholds should be included in RFPs for common ASE. The goals need to be near term, achievable and more realistic. Data elements need clarification and more reliable collection techniques need to be devised.

The lack of an appropriate data base has made developing in-house estimates and analyzing inputs very difficult. The uncertainty of the data base has been advanced by some as a reason for not developing LCC estimates at all. It is generally agreed that an accurate data base enhances any LCC management efforts. However, the literature will point out that even without a data base there is still a great deal of data available in the minds of design engineers.

The procurement of ASE creates some unique problems which impact the LCC of a major system. Delays in the submission of SERDs, lack of communications between programs, drawings in SERDs which do not have enough detail to support competition, failure to emphasize contractual requirements for LCC management on SE, all hinder efforts to manage and reduce LCC. The failure to identify SE requirements early in the life of a program has the potential of increasing the LCC of both the major system and the SE. To meet the IOC, PSE is predominantly purchased direct from the prime contractor, contracting officers are forced into sole source procurements due to limited time, and any interaction between support requirements and design is reduced.

The next chapter will discuss some recommended solutions and various ways of motivating the contractor to better manage LCC.

VI. ALTERNATIVE METHODS OF IMPROVING LIFE-CYCLE COST MANAGEMENT

A. INTRODUCTION

The previous chapter provided a discussion of the obstacles to managing life-cycle cost which have been identified by this research. This chapter continues the discussion by identifying ways in which the Navy can overcome these obstacles.

To overcome these obstacles, the research shows that the Navy must:

* Commit itself to the management of LCC early in the life of a system,
* Make the inclusion of LCC provisions mandatory for all RFPs for major systems, subsystems and support equipment,
* Provide sufficient information in RFPs to enable the contractor to develop realistic estimates,
* Insist upon the use of realistic vice optimistic LCC estimates, and
* Incentivize the contractor to manage LCC throughout the life of a program.

The research also indicates that contractors can be motivated to manage LCC by:

* Encouraging competition,
* The use of incentive fee contracts,
* The use of award fee contracts,
* Elevating LCC to the status of unit production cost (UPC), schedule and performance and making LCC a

mandatory source selection criteria, and

* Utilizing reliability improvement warranties.

B. DISCUSSION

1. Early Commitment to LCC

There is a perception by industry that the Navy is not fully committed to managing life-cycle cost and that not enough emphasis is being placed on managing these costs early in the life of a system [Ref. 11]. As was previously mentioned, management emphasis and commitment by both industry and the Navy is an essential element of this undertaking. To demonstrate the commitment to managing cost, the Navy needs to develop and implement LCC management policies and procedures and translate those requirements into contractual provisions. [Ref. 7:p. 39] The use of contractual provisions is a step towards making it clear to industry that the Navy is intent on managing LCC. "The principal motivators are competition and the knowledge that primary downstream cost drivers, such as MTBF, are to be measured . . . ." [Ref. 10: p. 377]

The mere inclusion of contractual provisions is not in itself sufficient to motivate the contractor to manage cost. To be effective they must be consistently applied throughout the program. [Ref. 6:p. 150] As previously stated, although the Navy has the legal right to enforce incentives at the end of contract performance, if progress towards reaching desired goals is not monitored and managed throughout the life of the contract, any economic benefits that may have come about will have been reduced or eliminated. "If the contractor perceives a lack of credibility, policy response will be reflective and fundamental changes will not be implemented." [Ref. 36:p. 31] When design-to-cost was first introduced, contractors believed that the emphasis and importance attached to the program by the Government program offices were primary motivating factors in organizational response [Ref. 36:p. 16].

Inclusion of the requirement to develop a total cost management plan and an LCC estimate in the RFP will emphasize the Navy's commitment from the beginning of the program. As the first formal contact with industry, the attitudes and priorities expressed in the RFP will be mirrored in the contractors' response.

Early inclusion of a cost management effort is important to derive the full economic advantage [Ref. 42:p. 12]. The researcher would conclude that emphasis on life-cycle cost creates an environment in which to be successful, the contractor must conduct design trade-off studies during the concept exploration phase where the greatest cost savings can be realized. "Systems support and readiness is an attitude, not a program, and the earlier it is considered in the acquisition process the greater the cost-effectiveness leverage." [Ref. 47:p. 7] Interviews indicated that mandatory inclusion of a total cost LCC management plan in the acquisition strategy is one means of assuring early commitment.

[Ref. 11] The acquisition strategy is a communications tool by which the program manager conveys his concerns for ownership costs to the various supporting elements of the program and thus sets the tone for future developments.

2. Inclusion of Life-Cycle Cost in RFPs

Life-cycle cost requirements should be included in all RFPs, not just those for major systems. The policy has been written and the implementing instructions are in place requiring the consideration of ownership costs throughout the life of a major system. The intent of the regulatory provisions is to apply to all procurements where managing the total cost of ownership would be cost-effective and beneficial to the Government. DoDD 4105.62, Selection of Contractual Sources for Major Defense Systems, states: "The principles established in this Directive also are applicable to acquisitions other than those for major systems . . . ." [Ref. 28:p. 1] Other Department of Defense policy documents reiterate this position. [Ref. 26:p. 2] In particular LCC goals, measurements and the establishment of an LCC management plan should be included in each RFP for support equipment and ultimately translated into contractual requirements.

The Hardman Program Managers' LCC Handbook for avionics equipment contains an example of the wording which might be included in all RFPs concerning total cost management:

> Life-cycle cost is considered to be the greatest concern in the procurement. Proposed design approaches will not

> be considered solely on the basis of their acquisition cost, but also on the likelihood that they will exhibit low operating and support cost. It is the Government's intention to procure a design which economizes on all resources, both current and future. To this end, minimization of the cost of individual resources (e.g., manpower or support and test equipment) is deemed unacceptable: instead the designer shall accept responsibility for minimization of total life cycle cost. This requirement shall be considered satisfied by the integration of life-cycle cost analysis in the design process. Appended to this solicitation are all materials required to carry out such analysis, as part of the design process. While bidders are not required to use these materials, they should recognize that the government intends to use them in the source selection process and that the requirement for their use shall be included in any contract which may arise from this solicitation. [Ref. 43:p. 3]

The sample RFP clearly states the Government's intention to manage cost. It places cost on a par with unit-production cost, schedule and performance and requires that LCC trade-off studies be conducted during the design process. The RFP also makes it clear that the total cost of ownership will be used as a source selection criterion and ultimately included in any contract which may arise from the solicitation.

Special emphasis should be placed on the wording: "appended to this solicitation are all materials required to carry out such analysis . . . ." The RFP should contain sufficient operational scenarios, environmental data and employment information from which to develop realistic estimates of life-cycle cost and cost management plans.

3. Information Contained in RFPs

The researcher would observe that many of the problems with managing ownership costs can be overcome by a well-structured request for proposal which contains sufficient information to develop realistic LCC plans and estimates. The RFP is the formal means by which information is conveyed to the contractor from which he will develop these figures. The quality or realism of those estimates is a direct reflection of the information provided.

To be effective, the RFP should emphasize realistic valuations, provide sufficient information from which to prepare estimates and clearly define the LCC goals and measurements which will be employed. [Ref. 33] One means of increasing the viability of an RFP is to use pilot RFPs. Government and industry would work together to identify the total cost goals, measurements, the cost structure and the LCC model to be used in developing plans and estimates prior to formalizing the RFP. The advantages of such an approach are:

* The costs which should be included would be better defined,
* Specific problems with the LCC model could be identified and resolved prior to formalizing the RFP,
* The information required by industry to prepare the estimates would be properly identified,
* Such an approach reduces the potential for problems once the formal RFP is sent to industry, and
* Industry's understanding of what is required is increased and consequently they are in a better position to respond with realistic cost estimates and management plans.

The DoD has recognized the potential of draft RFPs and encourages their use. The current Directive on source selection outlines the Government's position.

> The use of draft Requests for Proposal (RFPs) is encouraged to obtain feedback from prospective offerors. Draft RFPs should be as complete as possible, including a statement of work, specifications, data requirements, evaluation criteria, and general and specific provisions. Sufficient time should be allowed to permit prospective offerors to respond meaningfully. Feedback for consideration in preparing the final RFP should include identification of cost drivers, noncost-effective contract requirements, and any other changes that would enhance the acquisition program by improving system performance or by reducing life cycle costs. [Ref. 15:p. 6-7]

One disadvantage that a PM or contracting officer might point out is that the use of pilot RFPs will only lengthen already stretched program schedules. It is the researcher's view that the disputes avoided and the quality of estimates provided will more than compensate for the extra time spent.

4. <u>Realistic Vice Optimistic Estimates</u>

Obtaining realistic estimates is not something that can be mandated but rather something that will have to come about as a result of the PM's better uderstanding of the benefits and potential cost savings of an LCC management program.

It appears that Navy efforts to obtain realistic cost estimates are hindered by the structure of the bid process itself.

> At the outset of a program, our DoD bid process encourages substantial contractor over optimism in technical accomplishment, in schedule, and in cost. The contractor environment is one of competition to win the support of the evaluators of the proposal; thus the contractor very much caters to the evaluator's interests. [Ref. 32:p. 4-35]

This apparent dilemma is easily overcome by a demonstrated commitment by the Government to obtain realistic estimates and by verifying them with estimates developed in house. The Navy Program Manager's Guide points out that total life-cycle cost is a critical factor when evaluating a proposal and that contractor's estimates should be verified by independent estimates. It states:

> Cost estimates in the earlier stages of the acquisition process are far from precise, and independent estimates of development and LCC by an in-house activity are needed to establish a baseline against which to evaluate the validity of contractor cost estimates. [Ref. 32:p. 4-40]

As was pointed out earlier, the Government's ability to accurately estimate ownership costs is viewed by both industry and the Government as being ineffective. [Ref. 33] It follows that if the Navy is going to motivate or incentivize industry to submit realistic estimates, the Navy should have the capability to determine the realism of those inputs. The importance of independent estimates is reflected in the Directive on source selection.

> Independent cost estimates are necessary as a benchmark against which to compare proposals cost estimates. The realism of the offeror's proposal should be indicated by a ranking relative to the Government's estimate. [Ref. 28:p. 8]

5. Contractor Incentives to Manage Life-Cycle Cost

The program manager should motivate or incentivize the contractor to invest company resources to manage the cost of a system in a manner which is both cost-effective for the Government and profitable for industry. The steps which a

PM might follow are:

* Identify what factors influence the contractor's performance,

* Establish realistic goals and measurement criteria to measure a contractor's performance in designated motivational areas, and

* Determine the best approach to motivate the contractor to achieve the desired results.

The literature points out that performance may be influenced by the following factors [Ref. 48:p. xxiii]:

* Contractor motivation for increased reliability,

* Government credibility for warranty success,

* Competitive environment,

* Ability to accurately predict field reliability, and

* Subsystem contracting environment.

The subsystem contracting environment is especially important to managing LCC for support equipment. In many cases the prime, acting as a systems integrator, will subcontract out for support equipment. For a cost management program to be successful, the prime must be contractually required to include LCC provisions in all subcontracts. Any incentives or awards should also be passed on to the subcontractors.

The second step towards motivating the contractor is to establish goals, targets, and requirements in those areas which will influence the contractor's behavior which are realistic and attainable. The establishment of realistic goals and targets is greatly facilitated by the existence of an effective Government/industry interface, and by the use of realistic vice optimistic LCC estimates. Participation by the contractor in the development of cost goals and targets to be included in the RFP will tend to minimize the potential for misunderstandings which can lead to schedule delays and cost overruns. The contractor is bound by the terms of the contract so it is important that both parties fully understand the letter and the intent of the contract.

To establish achievable goals, it would be beneficial if negotiators understood the various technical and cost elements and how they interact to result in the life-cycle cost of a program. Assignment of goals which are either too high or too low are counterproductive resulting in increased vice decreased LCC.

> The use of incentives that exceed the range of reasonable expectation is wasteful of incentive effectiveness. Commitments based on guestimation rather than on assessment and experience are, at best, gambled contingencies and facetious criteria for award. [Ref. 3:p. 32]

Some of the tools available to a contracting officer to motivate the contractor to manage cost which are listed throughout the literature include:

* Encouraging competition,
* The use of incentive fee contracts,
* The use of award fee contracts,
* Elevating LCC to the status of unit-production cost, schedule and performance and making LCC a mandatory source selection criterion, and
* Utilizing reliability improvement warranties.

Each of the above mentioned approaches to motivating a contractor work equally well for major systems, subsystems and support equipment. To be fully effective, any incentives at the prime contractor level should be passed on to subcontractors.

a. Competition

Competition is a powerful tool which can be used to encourage effective management of total cost. When the market forces to support true competition exist and cost is used as an evaluation criterion during source selection on an equal basis with unit production cost, schedule and performance the incentive is there for the contractor to manage LCC from the beginning. An author stated: "Competition is the most important factor in making LCC contract requirements work easily." [Ref. 6:p. 153]

b. Incentive Fee Contracts

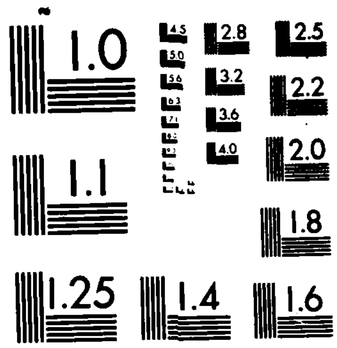
Incentive fees are defined in the <u>Acquisition Strategy Guide</u>:

> Defined, an incentive fee contract is a strategy to reward the contractor for meeting or exceeding defined goals and, in some cases, to penalize the contractor for failure to meet goals. The objective of an incentive fee contract is to motivate the contractor to meet or exceed target levels when there is uncertainty about the outcome and the contractor has some control of the outcome. [Ref. 17:p. 5-29]

The type of contract to use, whether it be a cost-plus-incentive-fee (CPIF) or a fixed-price-incentive-fee (FPIF) contract is dependent upon the degree of uncertainty. The CPIF contract is most appropriate when the

AD-A165 520 CONTROLLING LIFE-CYCLE COST: A MANAGEMENT PERSPECTIVE 2/2
(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA D L PORTER
DEC 85

UNCLASSIFIED F/G 5/1 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

uncertainties of performance preclude a fixed-price contract but are not so great as to require a cost-plus-fixed-fee contract. The FPIF contract is more applicable to situations where the goals are not easily quantified, such as in management. [Ref. 17:p. 5-29]

The proper structuring of incentive arrangements is important to avoid future disputes and to achieve the desired results. Realizing that the contractor will concentrate on those areas where the incentives are the greatest, it is important that the PM and contracting officer work together to structure the incentives which will accomplish the desired objectives. [Ref. 6:p. 137]

The advantages of an incentive fee contract are [Ref. 17:p. 5-30]:

* Greater realism in negotiating,
* Increased cost consciousness,
* Account for motivational variability, and
* Provide the contractor flexibility in meeting target values.

Some disadvantages are [Ref. 17:p. 5-30]:

* The cost and complexity of administration are increased,
* It is difficult to establish realistic targets,
* There is a tendency to create incentives for too many elements, leading to complex, poorly understood relationships,
* Contract complications arise from Government directed changes, and
* The profit motive, the essence of incentive contracting, may not be the prime motive of the contractor.

A major subcontractor for aviation support equipment commented that a disadvantage of an incentive fee arrangement is that it automatically casts both the Government and industry as adversaries. A by-product of this adversarial position is the deterioration of the interface which is so vital to the success of any program. [Ref. 33]

Another disadvantage to using incentive fees for controlling cost is a perception by industry that a contractor will receive the full incentive regardless of whether the goal is achieved or not. Two reasons given to support this claim are: 1) to make anything less than a full award is viewed by the program office as an admission of failure to overcome a major problem, and 2) goals are difficult to measure. [Ref. 11]

c. Award Fee Contracts

An award fee type of contract provides a means of applying incentives in contracts which are not susceptible to finite measurements of performance necessary for structuring incentive contracts. [Ref. 32:p. 41] An award fee is particularly useful during the early phases of procurement where the management effort of the contractor does not lend itself to quantitative measurement.

The amount of award fee to be paid is based upon a subjective evaluation by the Government of the quality of the contractor's performance, judged in light of criteria set forth in the contract. The intent of the criteria selected should be in terms that express results rather than causes or kinds of effects. The criteria must be fully developed, and the meaning and intent thoroughly understood by both parties. If there is no agreement on the criteria to be used or it is vague, the contractor will be confused trying to determine where to allocate his resources to maximize profit. [Ref. 32:pp. 41-42]

The advantages of an award fee contract are:

* Where firm, graduated, objective performance criteria cannot be set before work begins, a cost-plus-award-fee (CPAF) contract provides for subjective evaluation.

* A CPAF contract is flexible.

* Communication between the Government and the contractor is greatly improved because there is a closer working relationship than with other contract types. Furthermore, research has shown that contractor performance improves with increasing top-level Government-contractor interaction. [Ref. 49:p. 11]

* The award fee approach facilitates achievement of program goals by its shared management requirements, and by it's avoidance of the interposition on contractual or other barriers between Government and contract managers [Ref. 8:p. 1-12].

From an industry perspective the award fee contract has the advantage of avoiding the inherent penalties involved with an incentive fee arrangement. "With an award fee the contractor either gets the award or he doesn't. There is no loss or penalty for not achieving the goal." [Ref. 33]

d. Life-Cycle Cost as a Mandatory Source Selection Criterion

One approach to demonstrating to industry that the Navy is committed to the early and continued management of life-cycle cost is to make it a mandatory source selection criterion not only for major systems but subsystems and support equipment as well. "The Government must convince contract bidders that LCC is a significant consideration in the selection of a contractor and in the continued viability of the program." [Ref. 6:p. 252]

There is a perception by some that in the early phases of procurement operating and support cost projects are too uncertain to justify selection based on LCC. [Ref. 8:p. 2-8] The present feeling by industry is that this is no longer true. Ownership cost is being used as a source selection criterion and one contractor indicated that three contracts had been won on the basis of these projections. [Ref. 33]

Using life-cycle cost as a source selection criteria is not a new idea however, it is one that has been slow to catch on.

> In March 1981, the Acquisition Improvement working group suggested that reliability, maintainability, operational availability, and supportability be elevated to the status theretofore held by cost, schedule and performance. This was not to diminish the importance of these latter criteria, but only to establish the attention to the support disciplines, i.e., logistics, reliability, maintainability, and quality assurance, in order to enhance the overall operational suitability of a fielded system. [Ref. 38:p. 132]

As discussed with one official, if the Navy is going to use life-cycle cost as a source selection criterion then the costs which should be included need to be better defined [Ref. 11]. "Presently there is too much divergence, especially in the operating and support arena." [Ref. 11] There is a consensus that each party should only estimate those costs over which it exercises control. Those costs which are inherently governmental, such as base operating costs, should be estimated and incorporated into the industry estimates by the Government. [Ref. 33]

The Navy should fund research and development efforts to develop a standardized LCC model. The use of a standard model would facilitate evaluation and comparison of LCC proposals submitted and if centrally managed would enhance the ability to update and refine the model to further improve the accuracy of the estimates. The model does not necessarily have to be perfect. If everyone uses the same model there will be a consistency of errors. [Ref. 33]

e. Reliability Improvement Warranties

Mr. Michael P. Tucker explains that if the Government expects the contractor to actively pursue the reduction of operating and support costs then such an effort must be advantageous to the contractor. His views are expressed in this quotation:

> Clearly, arrangements need to be made to provide the manufacturer with a stake in the operating and support costs of the equipment. The production contractor must see potential benefits to himself in lower operating and support costs before he is likely to change design, adjust processes or take other actions enhancing reliability. Changes to traditional methods for performing maintenance actions must also be effected through new contractual concepts. [Ref. 50:p. 1]

One method of creating an interest in operating and support costs is by using a reliability improvement warranty (RIW). "Under an RIW, a contractor assumes responsibility on a fixed-price basis for repairing or replacing (as he sees fit) warranted units that fail during the warranted period." [Ref. 31:p. 1]

The use of such a warranty provides the contractor an economic incentive to reduce operating and support cost. The impact of an RIW on these costs is expressed as follows:

> The user generally attempts to hold down support costs by specifying minimum acceptable reliability and maintainability; but demonstration of these characteristics is an inexact process, as is cost projection based on them. In addition, the supplier is economically motivated to reduce the level of equipment characteristics that are basic determinants of support costs. However, in a warranty procurement, the contractor is responsible for virtually all repairs. A major portion of life-cycle costs thus becomes his burden, and he is more inclined to make higher initial outlays to assure reliability. [Ref. 23:p. 621]

Defined, a warranty is an enforceable promise given by a seller to a buyer that specifies the quality or performance capability of a product or service [Ref. 51:p. 24]. A warranty may be implied or expressed and may be classified as either a performance or design warranty which are the two basic groupings of warranties used by the Government.

The reliability improvement warranty (a performance warranty), is a fixed-price contractual incentive for improving operational reliability and maintainability. It requires that failures of the equipment during use be repaired at no charge to the Government for a specific period of time, usually for a period of five years with a minimum of three years.

Using an RIW places the responsibility for controlling costs with the contractor who is in the best position to control them. The objectives of an RIW are [Ref. 52:p. 7]:

* Improve reliability,
* Reduce life-cycle cost, and
* Shift the risk to the contractor.

The RIW also tends to increase the importance placed on reliability in relation to performance, schedule and initial cost by making it more profitable to consider reliability than to neglect it.

> Contractors who have been capable of designing and producing reliable hardware, did not do so because their rewards were realized from producing a high performance system for the least possible cost and not from the production of reliable equipment. [Ref. 50:p. 21]

The intent of an RIW is to motivate the contractor to design and produce equipment that will have a low failure rate and be economical to repair when it does fail, thereby reducing the life-cycle cost of the equipment to the Government. [Ref. 49:p. 2-24]

The literature will support the claim that to derive the maximum benefit from an RIW it is essential that the decision to include it in the acquisition strategy be made early and that contractual provisions be included during the concept exploration and design phases of the acquisition process. It is during these phases that the maintenance plan is formulated and design decisions which will determine future operating and support costs are made. "The designer determines reliability and can change it." [Ref. 6:p. 204]

Once the design is set and production has begun it is still possible to affect changes but it becomes increasingly more expensive as time progresses.

Before deciding on a particular course of action the program manager should carefully weigh the advantages, disadvantages and experienced problems of each of the alternatives under consideration.

The advantages of an RIW include [Ref. 6:p. 141]:

* An RIW motivates the contractor to improve the initial design for reliability and maintainability,

* Encourages the contractor to propose engineering changes after the product is in the field so as to improve reliability and maintainability further and to reduce the risk that repair costs, or the mean-time-between-failure (MTBF) correction costs, will cause cost overruns,

* Provides for reduced customer investment in handbooks, spares, test equipment, and maintenance training until the item has stabilized,

* Provides an early explicit value for maintenance costs for planning purposes,

* Provides an enforceable guarantee,

* Fosters, a closer working relationship between the contractor and field operators, and

* Places a greater emphasis on LCC.

From a contractor's viewpoint, an RIW provides for increased profit potential if the MTBF is maintained above the pricing base, provides for constant multi-year business, and provides the opportunity for the contractor to become more familiar with the operational reliability and maintainability of his equipment which should help in obtaining follow-on contracts. [Ref. 53:p. 9]

Some of the disadvantages of an RIW are:

* RIWs may result in reduced military self-sufficiency [Ref. 23:p. 28],
* Long term warranty provisions may present risks to small companies that would discourage their entrance into procurement competition [Ref. 53:p. 10],
* Increased administrative complexity [Ref. 54:p. 26], and
* It is difficult for contractors to predict their ultimate field reliability and warranty cost due to limited development program data [Ref. 36:p. 9].

Mary Ann Gillece has identified four conditions which will increase the effectiveness of a warranty. [Ref. 54:p. 26] They are:

* Warranties are best applied in a competitive environment,
* Warranties work best when selectively applied to specific components rather than complete systems,
* The equipment should be well-defined and based on established technology, and
* Warranties are best suited to fixed-price contracts.

Based on these criteria, the researcher would conclude that warranties could be effectively applied to support equipment.

In summary, the reliability improvement warranty is a contractual tool which can be used to economically motivate the contractor to consider reliability and maintainability. It places the responsibility for controlling costs with the contractor and makes it more profitable for him to consider reliability than to neglect it. Finally, the intent to use a warranty should be included early in the life of the system to enable supportability requirements to influence the design.

C. SUMMARY

Life-cycle cost estimates developed by both the Navy and industry tend to be over optimistic. Navy program managers are prone to be optimistic in their estimtes to win program approval. If they will serve as budget inputs, the tendency is to inflate them to provide a cushion for future contingencies. Contractors on the other hand, will be optimistic with their estimates in an effort to win the contract. Use of less than realistic cost estimates has the potential of harming a program by creating the appearance of cost overruns. Use of estimates which are not realistic degrades the benefits to be derived from a life-cycle cost management effort by establishing a less than accurate baseline.

A well-established, functioning, Government/industry interface is needed if the Navy is to be successful in managing life-cycle cost. The interface is presently characterized as being less than effective.

A well-structured request for proposal can be very beneficial to managing ownership costs. Not only does it provide the information to develop estimates, but it also highlights those areas which will be emphasized by the Navy. The problem arises from the fact that the operational scenarios, environmental data and employment information needed to develop cost estimates are generally lacking from RFPs. As one of the first pieces of formal correspondence with the contractor, the RFP sets the tone for the entire project.

The research shows that most contractors are of the opinion that the Government is not fully committed to managing life-cycle cost. This is evidenced by a failure to include and properly emphasize the LCC management effort in the RFP, the fact that program managers are evaluated based on the achievement of near term goals and not long term supportability, and a lack of understanding of the benefits to be derived from total cost management. It has been suggested, that to increase the emphasis on life-cycle cost, reliability, maintainability, operational availability, and supportability should be elevated to the same status as performance, schedule and unit production cost.

Placing an early emphasis on cost is important not only to demonstrate to the contractor the Navy's commitment, but also to derive the greatest economic benefit. The design engineer plays a vital role in determining the ultimate cost of ownership of a system. Eighty five to ninety percent of these costs are determined by the demonstration/validation phase.

From an industry perspective, it is not only important to have a strong interface with the buying office but with the end user as well. This interface is viewed as particularly important for support equipment. Site or field visits are beneficial to both the contractor and the Navy. For the contractor, the visits enable engineers to become more familiar with the fleet's requirements and bring them closer to the source of problems. The Navy benefits by having the contractor demonstrate the proper application of equipment. The end user is the ultimate source for data pertaining to operating and support costs. Their biggest contribution to the cost management effort is in providing reliable, factual data on a timely basis.

The inclusion of life-cycle cost goals and thresholds in major systems contracts have been sporadic, and non-existent for aviation support equipment. These goals and thresholds should be included in RFPs for this equipment. The goals need to be near term, achievable and more realistic. Data elements need clarification and more reliable collection techniques need to be devised.

The lack of an appropriate data base has made developing in-house estimates and analyzing inputs very difficult. The uncertainty of the data base has been advanced by some as a reason for not developing these estimates. It is generally agreed that an accurate data base enhances any cost management efforts. However, the literature will point out that even without a data base, there is still a great deal of data available in the minds of design engineers.

The procurement of aviation support equipment creates some unique problems which impact the total cost of ownership of a major system. Delays in submission of Support Equipment Recommendation Data (SERDs) which do not contain enough detail to support competition, failure to emphasize ownership costs during design reviews and an inconsistent application of contractual requirements for life-cycle cost management on support equipment, all hinder any efforts to manage and reduce the total cost of ownership of both the major system and the support equipment.

Each procurement will be different and will require a slightly different approach to managing life-cycle cost. The basics are the same though; life-cycle cost should receive early attention, be contractually required and monitored throughout the life of a program.

VII. NAVY PERSPECTIVE REGARDING THE PROBLEMS AND ISSUES OF MANAGING LIFE-CYCLE COST

A. INTRODUCTION

This chapter will explore the problems and perceptions concerning life-cycle cost management as seen by Navy program managers of major weapon systems and by Navy Support Equipment Acquisition Managers (SEAMs).

To facilitate the discussion, the problems and issues have been grouped in the following categories:

* Early commitment to managing life-cycle cost,
* Management emphasis on life-cycle cost,
* Life-cycle cost estimates,
* The life-cycle cost data base,
* Funding,
* Government/industry interface,
* Contractor incentives to manage LCC, and
* Positive life-cycle cost management.

B. DISCUSSION

1. Early Commitment to Managing Life-Cycle Cost

The emphasis placed on LCC for both major systems and support equipment will vary from program to program and is dependent on the program manager and the phase of the acquisition cycle the system is in. [Ref. 54] The majority of interviewees were in agreement that LCC, and in particular operating and support costs, should be considered early in the design phase where the greatest payoff could occur. [Ref. 54] This point is also supported by the literature. "LCC procurement planning should begin early in the contractual effort when the most advantageous procurement strategies can be adopted." [Ref. 1:p. 20] One author states that operating and support costs can be a major portion of LCC and should not be over-shadowed by low procurement cost.

> Operation and maintenance (O&M) costs (fuel, lubricants, parts, labor, etc.) could amount to as much as 75 percent of a piece of equipment's lifelong cost of ownership. This gives rise to the concern that unless support costs are given more than casual consideration, savings generated by low initial procurement costs may soon disappear because of abnormal life-cycle support cost. [Ref. 55: p. 15]

Although the operating and support costs can be a significant portion of the LCC for a major system, one interviewee pointed out that LCC design trade-offs do not receive as much attention for support equipment because the associated O&S costs are not as large a percentage of the total cost. [Ref. 54] He further explained that the big cost drivers such as fuel, lubricants and manning are generally not major problems for SE. Maintenance would be the biggest cost driver, particularly test and calibration. [Ref. 54]

A Navy cost analyst, while recognizing the need to consider LCC during the early stages of the acquisition process, pointed out that it is difficult to come up with realistic and reasonable estimates any earlier than the full scale development phase. [Ref. 11] "Even in the earliest stages, estimates, however imprecise, can indicate which system of several being considered would likely result in the lowest ownership cost." [Ref. 37:p. 14]

There is general agreement between those interviewed and the literature, that LCC should be considered early in the life of a program when the greatest economic benefits may be derived. Due to the fact that O&S costs for support equipment are typically not as large a percentage of the total cost as those for a major system, design trade-offs are not as heavily emphasized. Finally, life-cycle cost estimates even in the early stages of procurement, can be beneficial to the decision making process.

2. Management Emphasis on Life-Cycle Cost

The program manager (PM) plays a very important role in determining to what extent LCC will influence a program. As many PMs and Business Financial Managers (BFMs) will point out, the emphasis is on current expenditures and not on long term operating and support costs. [Ref. 56] The

> Many participants are pushed by time to achieve something significant in their tours and terms and, if it is necessary to choose between satisfying a current or future need, to decide in favor of the current one. [Ref. 8: p. 3-1]

literature highlights the fact that a PM is judged on program progress in the near term. "This environment encourages program managers to regard their systems as unique and discourages such things as hardware standardization and concern for follow-on support." [Ref. 4:p. 32] Such a philosophy does not appear to be in keeping with DoD's policy of obtaining affordable weapon systems. Affordability is defined in A-109 as "a function of cost, priority, and availability of fiscal and manpower resources . . . ." [Ref. 26: p. 6]

The attitudes of senior Navy officials to a large degree determine what areas are to be emphasized in a program. One BFM commented that no LCC requirements had been imposed on the program manager and that little or no emphasis was placed on LCC for his particular project. This approach appears to be contrary to DoD policy. As declared in DoDD 4245.3, it is the policy of the DoD to establish O&S parameters [Ref. 15:p. 1] and that PMs shall identify major life-cycle cost drivers and endeavor to contain them during contract performance. [Ref. 15:p. 4]

Even when requirements for total cost are imposed, there is concern by some that the emphasis is not genuine. "Senior Navy officials are more concerned with statuatory requirements than the impact of LCC on programs or budgets." [Ref. 56] Looking at the issue from a different perspective, one official raised the question; "What decisions are going to be changed?" [Ref. 57] Of those interviewed, the most common response was that a program would not be cancelled because of high anticipated ownership costs. [Ref. 56] A PM for a major system commented:

> There is a great deal of emphasis being placed on LCC at DSARC Milestones I and II. LCC estimates are being used for comparison purposes to select the most cost effective system. However, a program would not be cancelled due to

> an LCC estimate which was out of sight. The operational requirement would override. [Ref. 56]

The same sentiments were expressed by a senior official in the Support Equipment Division of NAVAIR. It was stated that upfront costs were the deciding factor and high downstream costs would not be cause to cancel a program. [Ref. 58]

Just as the PMs for major systems tend to question the real importance of LCC in the decision making process, the SEAMs also question the role which LCC plays in the selection of support equipment. One interviewee didn't know if the selection of a particular piece of support equipment was based on total cost, however, he did know from experience that life-cycle cost was not a factor during negotiations. [Ref. 59] An official in the Guidance and Control Section of the Support Equipment Division remarked that LCC is included in the selection process only so managers will be aware of them [Ref. 58]. Still another manager in the Avionics Section remarked that although the LICA was performed by NAEC there wasn't much emphasis placed on the results during the selection process [Ref. 60]. It was also stated that LCC estimates were not used during DNSARC reviews [Ref. 60].

As defined earlier, the Life Impact Cost Analysis (LICA) is a modeling effort to determine the lifetime support costs of any Automatic Test Equipment (ATE) decision. The SE Selection Guide does not place any restrictions on the use of LICA, yet in interviews with SEAMs it was stated that it is only being applied to major items of ATE. [Ref. 21] It was also stated that the usefulness of this analysis was further degraded by it being conducted too late in the process. In come cases, the analysis was performed after the selection had been made. [Ref. 21]

Of the program managers for major systems interviewed, all agreed that LCC should be considered for major systems [Ref. 57]. The literature also supports the claim and contends that the use of LCC, or segments of it, in procurement is an effective way to manage total system or equipment cost [Ref. 1:p. 20]. Furthermore:

> From a fiscal perspective, the LCC process as applied to an investment opportunity means that alternative courses of action are considered before a set of options is selected. The point to be made is that the total cost, not just the initial near term costs, should be considered as an input to the decision process. [Ref. 1: p. 8]

The SEAMs interviewed had differing opinions as to how much emphasis should be placed on ownership costs. There was concern over whether it was cost effective to do a total cost analysis, and if the analysis was done, what decisions would be affected. [Ref. 57] Not as much emphasis is being placed on LCC trade-off studies for SE due to a belief that the large cost savings possible for major systems are not possible for SE [Ref. 21].

To summarize, the present emphasis by Navy managers is on current expenditures vice long term operating and support costs. Those interviewed were in agreement that a program would not be cancelled due to high anticipated O&S costs. Interviewees in the Support Equipment Division echoed these sentiments and added that it may not be cost effective to do trade-off studies in all cases.

3. Life-Cycle Cost Estimates

The uncertainty of LCC estimates is occasionally advanced as a reason for not estimating them at all [Ref. 6:p. 67]. When Navy interviewees were asked how accurate these estimates were and how this would be known, the most frequent response was that there was no way of determining their accuracy [Ref. 61]. A Navy cost analyst went further and claimed that the inability to substantiate estimates is a major problem. "When it comes to make cuts in a program, if you can't prove or substantiate your figures, you are going to get out." [Ref. 11] As pointed out by this same individual, being able to substantiate estimates is essential not only to justify what you need, but also to justify what will happen if you don't get the funding [Ref. 11].

During interviews and in reviewing the literature, a number of explanations were offered to account for the apparent uncertainty in estimates. The most prevelant replies were:

* Both Government and industry are short on accountable historical life-cycle cost data [Ref. 7:p. 40],
* The amount of time needed to field a new system adds to the uncertainty [Ref. 8:p. 3-1],

* Cost models and techniques being used are ineffective [Ref. 37:p. i],

* It is difficult to estimate LCC for state-of-the-art technology [Ref. 11],

* Program offices do not provide sufficient information from which to develop reliable estimates [Ref. 11],

* It is difficult to separate recurring and non-recurring costs [Ref. 21], and

* There is no interface between the Navy and industry concerning LCC estimates [Ref. 57].

The necessity for the Government to be able to develop realistic estimates is highlited in the DoD Directive on source selection. It is explained that independent estimates serve as a means of determining the cost realism of proposals submitted and as a benchmark against which to compare proposal cost estimates. [Ref. 28:p. 8]

Interviewees for both major systems and SE stated that contractors were providing LCC estimates and updates however, they were not being analyzed. [Ref. 62] Some questions which might be raised here are: If the Navy is requiring and receiving LCC estimates and not using them, why are they required? Another question is why haven't the estimates been analyzed? An insufficient cost data base is probably one reason the estimates can't be analyzed but it is not the only one. Other explanation offered are:

* There is no commonly accepted work breakdown structure for Integrated Logistics Support (ILS),

* Each contractor will more than likely use a different estimating model, and

* Each contractor will classify various costs as he

thinks they should be classified which may or may not be consistent with the request for proposal. [Ref. 11]

To resolve the problem of varying models, one might conclude that a specific model should be called for in the RFP. As Captain Vigrass (NAVAIR Cost Estimating) points out, such an approach could be risky for the Navy because any problems which might arise relative to the model or the estimates, could be construed as being the responsibility of the Navy. [Ref. 21]

This section has put forth the idea that life-cycle cost estimates are shrouded in uncertainty. The necessity for the Government to be able to develop realistic estimates was pointed out and it was stated that those estimates and updates provided by the contractor are not being used.

4. Cost Data Base

A 1974 General Accounting Office (GAO) report, concerning life-cycle cost estimating, claimed that LCC has had limited applications in decisions affecting major systems acquisition [Ref. 37:p. i]. The reasons given were the uncertainty of the data used to develop estimates and a need for better cost models and estimating techniques. One of the recommendations given in the report was to improve the data used in developing LCC estimates. [Ref. 37: p. i]

Almost eleven years later the cost data base for life-cycle cost is still considered by some to be inadequate [Ref. 11]. Captain Vigrass does not share this opinion.

As he pointed out, there is currently in place a system to collect historical operating and support cost data. The system, referred to as VAMOSC (Visibility and Management of Operating and Support Costs), contains historical cost data which is readily available and easy to use. Captain Vigrass is quick to point out though, that the validity of the data base is dependent upon the quality of information input into the system. [Ref. 54]

On the other hand, a Navy cost analyst still contends that poor data collection and poor data bases are inhibiting efforts to estimate ownership costs. This interviewee agrees with the statement that the data base is only as reliable as the information input and cites several factors which tend to degrade the cost data base. The difficulties mentioned are:

* Each NARF (Naval Air Rework Facility) has a different standard of work measurement,
* Measurement of time is not the same between NARFs, and
* The manner in which costs are allocated to a particular job differs between NARFs. [Ref. 11]

As was discussed in an earlier chapter, one industry executive felt that the biggest contribution an operational command or end user could make would be to provide reliable, factual data on a timely basis [Ref. 33].

There is no difference of opinion concerning the historical cost data base for aviation support equipment (ASE). All those interviewed agreed that there was no such data base for SE and the lack of it was impairing the ability to estimate and analyze LCC. [Ref. 62] As Captain Vigrass mentioned: "There is a need for good, accurate data which is readily available. Not only is the cost data needed but the technical data to describe the cost is needed as well." [Ref. 21]

The reasons given to support the claim that a historical cost data base is needed were the same for both major systems and support equipment. Cost data bases are needed to develop and refine cost estimating relationships (CERs) used to determine ownership costs. As stated by a Navy official: "A historical data base would not be useful for analogies because it rarely works. However, the use of such a data base would be beneficial in developing CERs." [Ref. 60] Historical cost data bases are an additional tool which may be used by the Navy to validate contractor provided estimates. The necessity for independent estimates was expressed by:

> To use LCC as a real factor in source selection with the objective of incentivizing contractor emphasis in the design phase . . . there must be follow-up procedures to validate initial contractor estimates and an independent assessment of estimates. [Ref. 63:p. 14]

Program Manager and cost analyst interviewees, mentioned that data collection is expensive and it may not be cost effective to pursue in all cases [Ref. 21]. A cost reducing alternative would be to collect data only on certain high value parts [Ref. 37:p. 7]. A 1974 GAO report on cost estimating states: "An OSD official . . . estimated that about 80 percent of the depot maintenance cost is associated with about 15 percent of a systems components." [Ref. 37:p. 7] Another approach offered by an aerospace ILS manager would be to limit the number of aircraft for which cost data would be collected [Ref. 33].

In summary, the need for a reliable cost data base for both major systems and aviation support equipment, has been recognized for a number of years. There is a system currently in place to collect O&S cost data for major systems however, the credibility of the data is questioned by some. There is no such data base for support equipment. Historical cost data bases are needed to develop and refine CERs and to aid in validating contractor provided estimates. Due to the cost associated with data collection it may not be economically feasible to collect data for an entire system. Alternatives offered are collecting data for high cost items or limiting the sample population.

5. Funding

In addition to the difficulties encountered in estimating total cost, funding constraints have seriously hampered efforts to manage cost for both major systems and support equipment [Ref. 60]. Funding constraints in the early years of a program [Ref. 2:p.36] and the fact that Congress votes separate appropriations for procurement funds and operating and maintenance funds [Ref. 4:p. 32] have been identified as drawbacks to effectively managing LCC.

The lack of adequate up-front funding limits the amount of design trade-off studies which may be conducted. Testability has been cited by some as being one method of reducing SE costs. The problem arises from the fact that efforts to improve testability and performance have not been separately funded, and when faced with a budget crunch, funds earmarked for testability were expended to meet performance requirements. [Ref. 58] A SEAM remarked:

> On almost all of the programs, there have been problems in achieving performance. Funds allotted for testability are subsequently expended to achieve performance goals. Testability is not funded separately. [Ref. 58]

High initial costs requried to achieve total cost savings may also restrict the number of alternatives to those which can be achieved within available funds [Ref. 58] The alternative selected may or may not have the lowest projected cost. This means that the system with the lowest ownership cost may be eliminated from the competition. This brings up a point which was made earlier. Accurate LCC estimates are needed to justify up-front funds and to identify the consequences if such funds are not made available. [Ref. 11]

The lack of funds, coupled with the PM's need to meet near term goals, forces him to consider near term expenditures often at the expense of future operating and support costs. A Navy ILS manager for a major system echoed these sentiments. He states that when the budget crunch came, the PM dropped all ILS incentives and deferred funding most of these incentives to the first production year. [Ref. 11] Another program manager for a program which was experiencing a funding shortfall, cut the data requirement needed for future logistics support [Ref. 4:p. 32]. Perhaps the reason for this is that Congress funds procurement and operating and support costs separately [Ref. 6:p. 4]. This, linked with the focus of attention of senior Navy officials on current expenditures vice long term operating and support costs, causes the PM to give priority to procurement costs [Ref. 56]. As expressed by an official working on the Consolidated Automated Support System (CASS): "The focus is on current dollar, R&D and production, not operating and support." [Ref. 60]

Insufficient up-front funding to support LCC design trade-off studies appears to undermine the objective of the DoD to obtain affordable systems. As stressed in DoD Directives, "A cost effective balance must be achieved among acquisition costs, ownership costs of major systems, and system effectiveness in terms of the mission to be performed." [Ref. 26:p. 3]

A synopsis of the funding problem reveals that a lack of up-front funding to conduct design trade-off studies may be increasing the total cost of a system by neglecting logistics considerations early in the life of a system. Limited funding may also eliminate alternatives which, over the life-cycle of a system, may be the most effective in terms of performance and offer the lowest total cost of ownership.

6. Government/Industry Interface

In a previous chapter, it was pointed out that the Government/industry interface concerning LCC management was characterized as being less than effective. As previously quoted, Mr. Frank of Litton Guidance and Control Section, stated during an interview that the company was not aware of how NAVAIR was organized to handle or develop LCC estimates, it was not known how the estimates were used, and his company had received no feedback concerning the estimates or updates submitted. [Ref. 33]

When Navy officials were asked to characterize the interface some of the responses given were:

* There is no Government/industry interface [Ref. 58],
* There is little interface with the contractor [Ref. 21], and
* There is no interface with industry except at the debrief after the contract has been awarded [Ref. 57].

This researcher has observed that although industry representatives were supportive of a strong interface, Navy officials, although generally agreeing that the interface should exist, were not as positive about their position.

7. Contractor Incentives to Manage Life-Cycle Cost

When asked the question how the contractor can be motivated to manage LCC, a typical response was: "By imposing reliability and maintainability thesholds on the contractor." [Ref. 59] One support equipment aquisition manager claimed that while LCC is not specifically called for in solicitations, the contractor is being motivated to control it by including reliability, maintainability and supportability goals in the solicitation [Ref. 59]. Although reliability and maintainability are only subsets of the total cost of ownership, they determine the largest part of the operating costs. Control over both of them minimizes cost [Ref. 6:p. 237].

The inclusion of reliability and maintainability requirements is also in keeping with DoDD 4245.3, Design to Cost. This Directive calls for the establishment of DTC parameters for O&S such as "unit operating crew and maintenance manpower requirements or operational and logistics reliability and maintainability . . . ." [Ref. 15:p. 3]

Another common reply was that the contractor is motivated to consider LCC due to competition. In the words of a major system PM: "The primary contractor motivation is competition and the use of LCC as a source selection criterion." [Ref. 56] He further claimed that competition as a motivational tool was working.

8. <u>Applications of Life-Cycle Cost Management</u>

Life-cycle cost management is not being totally neglected by the Navy on either major systems or support equipment. Two major programs which have had a great deal of emphasis placed on total cost are the JVX (or V22) and CASS (Consolidated Automated Support System).

As stated by Colonel Creech, the Program Manager for the JVX: "There is a great deal of emphasis being placed on

LCC considerations." [Ref. 64] To help cultivate design trade-offs to enhance supportability, the management effort for the JVX is structured so that the Logistics Element Manager (LEM) must sign all engineering drawings. The cost estimating team for the JVX is also compiling a lessons learned package detailing the LCC management effort undertaken. [Ref. 64] Larry Stahl, a Navy ILS manager working on the JVX program, pointed out that LCC teams differ from project to project. As a result, there is a lack of corporate knowledge needed to avoid previous pitfalls. [Ref. 11] He views the maintenance of a lessons learned package as being a very valuable means of capturing the knowledge gained from experience.

The necessity of a lessons learned package is alluded to in the Design to Cost Directive. It states that "DTC efforts . . . shall provide an audit trail of the impact of these changes on DTC parameters." [Ref. 15:p. 2]

In the realm of aviation support equipment, there is a great deal of emphasis being placed on managing ownership costs for CASS [Ref. 60]. Early efforts to manage LCC included the requirement that unlimited data and rights be given the Government for the system. The objective is to develop a reprocurement package to support future competition through breakout which could reduce LCC. Cost analyst Bill Woodbury, remarked that the system is being designed from the beginning to enhance supportability. [Ref. 62]

The contractor is required to manage LCC as described in the Statement of Work (SOW). It states that the primary criterion for evaluating design changes during design reviews is life-cycle cost. Furthermore, the contractor is required to consider the impact of any proposed changes on life-cycle cost. [Ref. 60]

The emphasis placed on LCC for the CASS program is evident at all levels of the chain of command. This is reflected by the comment that at the next major milestone, LCC and supportability will be given the same emphasis as technical requirements. [Ref. 60]

C. SUMMARY

This chapter has explored the major life-cycle cost issues as presented by Government interviewees. It was stated that life-cycle costs should be considered early in the acquisition process when design trade-off studies can be conducted to identify the most cost effective alternatives. Although LCC should be considered early, LCC management efforts are hampered by a lack of funding and insufficient data bases. The lack of up-front funding creates an environment where the emphasis is placed on current expenditures, often at the expense of future logistics support costs.

Historical cost data bases which either do not exist, or contain questionable data, complicate Navy efforts to develop independent estimates or analyze LCC estimates provided by the contractor. In many cases, estimates provided by the contractor were not evaluated.

It was pointed out that the uncertainty of the LCC estimates is often cited as a reason for not developing them at all. However, it should again be stressed, LCC estimates are essential to support budget requests. Various factors contributing to the uncertainty of LCC estimates include insufficient data bases, lack of funding, a lengthy procurement process, lack of information, difficulty in distinguishing recurring and non-recurring costs and an ineffective interface with industry.

On the positive side, life-cycle cost is receiving management attention in some areas. Both the JVX and CASS Programs have had a great deal of emphasis devoted to this area. Each program has undertaken initiatives to enhance the probability of reducing future O&S costs. The JVX program has given the logistics element manager the opportunity to review and sign engineering drawings. CASS is planning for reduced LCC through the use of a reprocurement data package to support competitive breakout of parts.

Perhaps the most important step which has been taken to improve the LCC management process is the development of an LCC lessons learned package by the JVX management team. Such an effort could be very useful on future programs.

VIII. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

Life-cycle costs must be considered early in the acquisition process when support considerations can still influence systems design. The views of both Navy officials and representatives of the aerospace industry expressed in Chapters V and VII support this contention. Support equipment requirements, which may constitute 10 to 50 percent of the cost of the prime equipment, are identified too late in the procurement cycle to affect the design of the major system and too close to the initial operational capability to permit procuring the item in the most effective way. As pointed out in Chapter VII, design trade-offs are not heavily emphasized for aviation support equipment.

Navy program managers are not fully committed to managing life-cycle costs. This position is supported by published works and by interviews with program managers and acquisition managers for aviation support equipment. This is due primarily to the fact that PMs are evaluated on the basis of current expenditures and not on long term operating and support costs. Contributing to the problem is the fact that procurement and support costs are funded separately. Managers are not willing to sacrifice procurement dollars to enhance long term supportability. The problem is particularly accute for support equipment where, as discussed in Chapter VII, there has been little or no emphasis placed on life-cycle cost with the exception of automatic test equipment.

The regulatory framework concerning the management and control of the ownership costs of a major system is well-established, but the policies are not being consistently applied. As discussed in Chapter IV, the Directives emphasize the importance of managing cost throughout the life of a system. However, the policies and procedures are not consistently followed and there is little evidence that the provisions of the Directives are being applied to aviation support equipment. The emphasis continues to be placed on unit-production cost vice, a balance between total cost, unit-production cost, schedule and performance. Provisions for managing ownership costs which are included but are being inconsistently applied are:

* Cost is defined as the total cost of ownership, not unit-production cost,

* LCC management should be included in the acquisition strategy and emphasized during concept exploration,

* Independent cost estimates should be used where feasible for comparison purposes and to determine cost realism, and

* Appropriate trade-offs among investment costs, ownership costs, schedules and performance should be conducted.

The Government/industry interface relative to managing ownership costs is ineffective. Industry and Navy representatives both agree that the Government/industry interface is ineffective. This conclusion is supported in Chapters V and VII. While industry appears to be very anxious to improve communications, those Navy interviewees did not seem to share their enthusiasm. When estimates are provided by the contractor, the Navy is not providing any feedback to the contractor as to their validity or for what purposes the estimates are being used.

Requests for proposals do not contain adequate program information to facilitate the development of life-cycle cost estimates, by either Government or industry cost analysts, and attention to ownership costs is not adequate. Industry and Government representatives, as discussed in Chapters V, VI, and VII, have characterized RFPs as being vague with regards to LCC, lacking of LCC goals and management requirements and containing insufficient program information to develop meaningful estimates. Information which has been identified as insufficient includes operational scenarios, employment information and environmental data.

Provisions to monitor the total cost of a system have been lacking from requests for proposals for aviation support equipment. The necessity of managing life-cycle costs for major weapon systems is equally applicable to aviation support equipment. Yet, as discussed in Chapter V the requirements are not being consistently applied.

The validity of life-cycle cost estimates prepared by the Navy is questionable. Navy cost analysts for major systems must rely on the historical cost data contained in VAMOSC to develop their estimates. The reliability of this data is only as good as the quality of the input, which varies between activities. Analysts for aviation support equipment have no such data base to work with. Furthermore, program managers tend to be optimistic in their estimates of life-cycle cost to ensure the survival of their program. When used to prepare budgets, ownership costs are inflated to provide a cushion for future contingencies.

The ability to develop accurate life-cycle cost projections for aviation support equipment is hindered by the non-existence of a historical data base for operating and support costs. Navy managers agree that while there is a system for collecting operating and support cost data for major systems no such system exists for aviation support equipment. The lack of this information impairs the ability of a cost analyst to develop LCC estimates and to evaluate estimates provided by the contractor.

It is the policy of the DoD to procure affordable systems. This is equally applicable to both major systems and aviation support equipment. This position is supported in Chapters IV, V, and VII. While the Directives and Instructions were written to cover the procurement of major systems, many specifically state that the policies and provisions are equally applicable to less than major systems.

B. RECOMMENDATIONS

The management principles, goals and objectives contained in DoD Directives pertaining to major systems acquisition should be applied to aviation support equipment. As explained in DoDD 5000.1, the management principles and objectives described therein shall also be applied to the acquisition of defense systems not designated as major, e.g., aviation support equipment. Training should be conducted within the Support Equipment Division to familiarize personnel at all levels with the policies concerning, and the benefits to be derived from life-cycle cost management. Life-cycle cost should become as familiar a phrase as competition or reliability and maintainability. The commitment to control cost must start at the top. When reviewing decisions senior officials should insist on reviewing the cost trade-off analysis which was conducted.

The provisions of the SE Selection Guide should be expanded to include all aviation support equipment. The procedures followed in selecting automatic test equipment are based on sound business principles and are applicable to all items of aviation support equipment. Realizing that not all procurements can benefit from a life-cycle cost analysis, a dollar threshold should be established below which it would not be economically feasible to pursue extensive LCC management efforts. At a minimum, a life impact cost analysis (LICA), or some abbreviated form of a LICA, should be performed for each procurement. The LICA should be given more than a cursory review when making the final selection.

The Navy should emphasize realistic vice optimistic estimates. It is pointed out in Chapter VI that although initial estimtes are far from precise, they are still needed to establish a cost baseline. Furthermore, the failure to use realistic cost estimates may do harm to a program by creating the appearance of cost overruns. Independent Government estimates should be developed and compared with industry estimates to determine cost realism. Initial estimates should be monitored and refined as more data become available. To do this, a reliable system is needed to collect O&S cost data for both major systems and ASE. The regulatory framework to implement this recommendation is already included in current DoD Directives and in the SE Selection Guide.

A cost data base for operating and support costs containing not only cost data but the related technical data, must be developed for aviation support equipment. If costs are to be accurately estimated, then a data base is needed to develop cost estimating relationships and to substantiate estimates prepared by Navy and industry cost analysts. The ability to accurately estimate life-cycle costs will go a long way towards convincing Congress of the economic advantages of managing LCC early in the life of a program. Further research should be conducted to determine the feasibility of incorporating support equipment into the VAMOSC system.

To demonstrate the Navy's commitment to managing life-cycle cost, it should be given the same status held by unit production cost, schedule and performance and made a mandatory source selection criterion. It has been stated that the RFP establishes the goals and objectives which will be given priority throughout the procurement process. RFPs should be worded in such a manner that there is no mistake that life-cycle cost will be weighted equally with unit-production cost, schedule and performance during the source selection process. This action will force contractors to seek a balance among the four elements just mentioned if they are to be successful in their efforts to win the award.

The Government/industry interface pertaining to life-cycle cost management needs to be strengthened. A weak interface impairs the Government's ability to accurately determine and manage the total cost of a system. Industry has a wealth of knowledge concerning cost management which, when shared with the Government through open communications, can result in cost savings for both parties. One means of improving this interface is through the increased use of draft RFPs. Contractor field visits should be reinstated and funded to improve the interface with the end user. In addition when a contractor provides estimates he should be provided a copy of the analysis performed by the Government to enable him to refine his cost model or identify discrepancies in the analysis.

Requests for proposals must contain sufficient information to permit the development of reliable cost estimates.

The intent to manage life-cycle cost must be clearly stated in the RFP. Goals and thresholds should be included and they must be realistic, near term, and achievable. The data elements needed to track performance must be identified and then costs monitored throughout the life of a system. Information currently lacking from RFPs are adequate operational scenarios, environmental data, and employment information. Without this information cost estimates developed will continue to be unreliable. This recommendation is applicable to major systems and aviation support equipment. The use of draft RFPs is one means of assuring that the contractor receives adequate information. A draft RFP provides the opportunity for contractors to raise questions, point out errors and to identify what supporting information is needed.

The use of draft RFPs should be increased. Draft RFPs may be used to identify cost drivers, noncost-effective contract requirements and any changes that will improve system performance or reduce the total cost of ownership. Draft RFPs are currently underutilizied and their use should be increased. The use of draft RFPs is encouraged by DoDD 4105.62, Selection of Contractual Sources for Major Defense Systems.

Life-cycle cost estimates provided by the contractor must be utilized. An analysis of contractor provided inputs can lead to the refinement of cost models being used by both the Navy and industry. Realistic estimates provided by the contractor may be used to support budget request and to justify the requirement for additional up-front funding to support design trade-off studies.

The Navy must mandate life-cycle cost goals and thresholds as opposed to the parameters currently required by DoDD 4245.3, Design-to-Cost. As defined in current Directives a goal is a firm cost or value which should be attained, whereas a parameter is only a measurable value to be used as design considerations and management objectives for subsequent life-cycle phases. Assigning goals, vice parameters, gives ownership costs added visibility. This is brought about by the fact that goals must be included in the Secretary of Defense Decision Memorandum which is submitted to the Secretary of Defense for approval.

A lessons learned package should be centrally maintained for all life-cycle cost management programs undertaken for major systems. While conducting this research it was pointed out that each time a life-cycle cost management effort was implemented the wheel had to be reinvented. Cost management efforts and LCC models used had not been documented nor, with the exception of one program, were the lessons learned recorded. By requiring that a life-cycle cost lessons learned package be maintained for each major program the corporate knowledge gained through experience will not be lost. This package could reduce the number of problems encountered on future programs and help in improving the Government's overall capability to accurately estimate and manage cost. Such a package would also minimize the adverse effects to a constant changeover in personnel.

C. AREAS FOR FURTHER RESEARCH

Research conducted for this report has provided the basis for further study and action in the following areas:

* An examination of the feasibility of incorporating operating and support costs for aviation support equipment into the VAMOSC system.

* A cost-benefit analysis to determine the threshold below which it would not be feasilbe to conduct a life-cycle cost analysis.

* The development of a source selection guide to be applicable to all types of support equipment as opposed to just ATE.

* A case study of a program to determine how life-cycle cost principles were applied and their effectiveness. Two programs which could be evaluated are the JVX and CASS programs.

APPENDIX

LIST OF ABBREVIATIONS

ASE	Aviation Support Equipment
ATE	Automatic Test Equipment
BFM	Business Financial Manager
CAIG	Cost Analysis Improvement Group
CASS	Consolidated Automated Support System
CEBS	Cost Element Breakdown Structure
CER	Cost Estimating Relationship
CPAF	Cost-Plus-Award-Fee
CPIF	Cost-Plus-Incentive-Fee
CSE	Common Support Equipment
DCP	Decision Coordinating Paper
DEMVAL	Demonstration and Validation
DOD	Department Of Defense
DODD	Department Of Defense Directive
DSARC	Defense Systems Acquisition Review Council
DSMC	Defense Systems Management College
DTC	Design-To-Cost
DTLCC	Design-To-Life-Cycle Cost
DTUPC	Design-To-Unit Production Cost
FPIF	Fixed-Price-Incentive-Fee
FSD	Full-Scale Development
GAO	General Accounting Office
GSE	General Support Equipment
ILS	Integrated Logistics Support

IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
JMSNS	Justification for Major Systems New Starts
LCC	Life-Cycle Cost
LEM	Logistics Element Manager
LICA	Life Impact Cost Analysis
LORA	Level of Repair Analysis
MTBF	Mean Time Between Failure
NAEC	Naval Air Engineering Center
NARF	Naval Air Rework Facility
NAVAIR	Naval Air Systems Command, Washington, D.C.
O&M	Operation and Maintenance
O&S	Operating and Support
OMB	Office of Management and Budget
OPEVAL	Operational Evaluation
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
PM	Program Manager
PRE	Program and Risk Evaluation
P^3I	Pre-Planned Product Improvement
PSE	Peculiar Support Equipment
RFP	Request For Proposal
RIW	Reliability Improvement Warranty
R&D	Research and Development
SCP	System Coordination Paper
SDDM	Secretary of Defense Decision Memorandum

SE	Support Equipment
SEAM	Support Equipment Acquisition Manager
SEM	Standard Electronic Module
SERD	Support Equipment Recommendation Data
SESA	Support Equipment Selection Analysis
SOW	Statement Of Work
SPM-SE	Special Program Manager-Support Equipment
T&E	Test and Evaluation
TAAF	Test Analyze And Fix
TPS	Test Program Set
UPC	Unit-Production Cost
VAMOSC	Visibility And Management of Operation and Support Cost
VE	Value Engineering
VECP	Value Engineering Change Proposal

LIST OF REFERENCES

1. Military Handbook MIL-HDBK-259 (NAVY), Life Cycle Cost in Navy Acquisitions, 1 April 1983.

2. Emmelhainz, Margaret A., "Innovative Contractual Approaches to Controlling LIfe-Cycle Costs," Defense Management Journal, second quarter, 1983.

3. Riegle, Nyle N., Improving System Affordability, paper presented at the 21st. Annual Technical Symposium, Association of Scientists and Engineers of the Naval Sea Systems Command, March 1984.

4. Office of Federal Procurement Policy, Report to the Congress, Review of the Spare Parts Procurement Practices of the Department of Defense, June 1984.

5. Merritt, Terry and Vandenburg, Thomas, Naval Aviation Support Equipment Acquisition Policies and Procedures in the 1980's, Master's Thesis, Naval Postgraduate School, Monterey, California, September 1984.

6. Seldon, Robert M., Life Cycle Costing: A Better Method of Government Procurement, Westview Press, Inc., 1979.

7. Frayer, A. M., "Life Cycle Cost: An NSIA Review," Defense Management Journal, Vol. 12, No. 4, October 1976.

8. White, Richard P., The Framework for Life-Cycle Cost Management, Logistics Management Institute, January 1982.

9. Earles, Don, "Techniques for a Multifaceted Discipline," Defense Management Journal, Vol. 12, No. 1, January 1976.

10. Farrell, Thomas G., and Timperlake, Edward T., "Project METEOR: Motivating Everyone to Enhance Operational Reliability/Maintainability," Proceeding of the Seventh Annual Acquisition Research Symposium, June 1978.

11. Personal interview with Larry Stahl, ILS Manager, Naval Aviation Logistics Center, (NALC 633), Patuxent River, Maryland, August 2, 1985.

12. Department of Defense, Federal Acquisition Regulation, Volume I, parts 1-51, April 1, 1984.

13. SE Selection Guide, Naval Air Systems Command (NAVAIR-5522), Washington, DC, June 1981.

14. NAVAIRINST 5400.1B, Naval Air Systems Command Headquarters Organization Manual, August 1980.

15. Department of Defense Directive 4245.3, Design To Cost, April 6, 1983.

16. DAR Supplement NO. 6, DoD Replenishment Park Breakout Program, June 1, 1983.

17. Acquisition Strategy Guide, Defense Systems Management College, Fort Belvoir, Virginia, July 1984.

18. Bellaschi, Jules J., and Morrow, Garcia E., "A Cultural Change: Pre-Planned Product Improvement," Concepts, Vol. 5, No. 3, Summer 1982.

19. Phone interview with A. M. Piermatteo, Assistant Director, Support Equipment Division, Naval Air Systems Command, Washington, DC, November 21, 1985.

20. Dobbler, Lee Burt, Purchasing and Materials Management, McGraw Hill Book Company, 1984.

21. Telephone interview with Casey Bahr, Head, Requiremens and Acquisition Section, Support Equipment Division, Naval Air Systems Command, Washington, DC, October 23, 1985.

22. Commander, Naval Air Systems Command Letter 53424/MDM serial 06/1795, dated 12 June 1978.

23. Knight, C. R., "Warranties as a Life-Cycle Management Tool," Defense Management Journal, Vol. 12, No. 1, January 1976.

24. Inventory Management, A Basic Guide to Requirements, Determination in the Navy, Department of the Navy, undated.

25. Office of Management and Budget Circular A-109, Major Systems Acquisitions, April 5, 1976.

26. Department of Defense Directive 5000.1, Major System Acquisition, March 29, 1982.

27. Department of Defense Directive 5000.2, Major System Acquisition Procedures, March 3, 1983.

28. Department of Defense Directive 4105.62, Selection of Contractual Sources for Major Defense Systems, January 6, 1976.

29. Department of Defense Directive 5000.3, Test and Evaluation, April 11, 1978.

30. Department of Defense Directive 5000.4, OSD Cost Analsis Improvement Group, October 30, 1980.

31. Gordon, Harvey J., "The Role of the Contract in Systems Acquisition," Defense Management Review, Winter 1982.

32. Navy Program Managers Guide, Headquarters Naval Material Command, 1985 Edition.

33. Personal interview with Daniel Frank, ILS Manager, Advanced Program Requirements, Litton Guidance and Control Systems, Woodland Hills, California, September 10, 1985.

34. Boileau, O. C., "I Dreamed We Went Nowhere in Our Solid Gold Airplane," Defense Management Journal, Vol. 12, No. 1, January 1976.

35. Results of the Acquisition Strategy Workshop, Defense Systems Management College, Fort Belvoir, Virginia, May 1-2, 1984.

36. Institute for Defense Analysis, Contractor Initiatives for Reliability, Maintainability, and Cost Improvement, by David C. Weimer, September 1977.

37. General Accounting Office Report, Life Cycle Cost Estimating--It's Status and Potential Use in Major Weapon System Acquisitions, December 30, 1974.

38. Solomand, John P., "Contractor Incentives to Improve Reliability and Support," Concepts, Summer 1982.

39. Personal interview with Andrew Cozzolino, Group Engineer, Support Equipment Engineering (SEE), Lockheed, Burbank, California, September 9, 1985.

40. Stansberry, J. W., "Source Selection and Contracting Approach to Life Cycle Cost Management," Defense Management Journal, Vol. 12, No. 1, January 1976.

41. Personal interview with Frank Fritsche, Vice President for Contracts, Teledyne Systems Corporation, Northridge, California, September 9, 1985.

42. Bennett, John J., "Comment," Defense Management Journal, Vol. 12, No. 1, January 1976.

43. Butler, Robert A., and Neches, Thomas M., Hardman Program Manager's LCC Handbook, Avionics Equipment, Department of the Navy.

44. Personal interview with A. T. Harcarik, Group Engineer, Support Equipment Engineering (SEE), Lockheed, Burbank, California, September 9, 1985.

45. Usery, Matz, Cost Accounting Planning and Control, South-Western Publishing Company, eigth edition, 1984.

46. Personal interview with Ed Main, Support Equipment Logistics Division (NAVAIR-417), Naval Air Systems Command, Washington, DC, August 1, 1985.

47. Cochoy, Robert E., "Improving System Support and Readiness," Program Manager, September - October 1984.

48. Institute for Defense Analysis, Cost Analysis Group, Report S-483, The Impact of Reliability Guarantees and Warranties on Electronics Subsystem Design and Development Programs, by David C. Weimer, October 1976.

49. Downing, Edward J., Grosson, Joseph, Schwartz, Leonard, and Weaver, Carl, "Contract Type," Program Manager, May-June 1984.

50. Tucker, Michael P., In Defense of the RIW, Florida Institute of Technology, June 2, 1980.

51. Vesco, John A., "Warranties-Did I Agree to That?", Contract Management, February 1984.

52. Gandara, Arturo and Rich, Michael D., A New Look at Warranties in Defense, Rand Corporation, April 1978.

53. Bell, Robert C., Warranties in DoD-Effective of Expensive?, Armed Forces Staff College, April 19,1976.

54. Gilleece, Mary Ann, "The Warranty Tool," Defense, February 1984.

55. "Life-Cycle Cost: A New Form of Consumer Information," The Journal of Consumer Research, March 1980.

56. Telephone interview with Lt. Col. M. F. Pixton, USMC, Program Manager, H-1/Th-57/Ov-10, Naval Air Systems Command, Washington, DC, October 16, 1985.

57. Telephone interview with Bill Vardeman, Cost Analysis, Naval Air Systems Command, October 18, 1985.

58. Telephone interview with Richard Simmons, Head, Guidance and Controls Section, Support Equipment Division, Naval Air Systems Command, Washington, DC, October 23, 1985.

59. Telephone interview with David Sutherland, Acquisition Manager, Aircraft Handling/Inspection/Servicing Equipment Section, Support Equipment Division, Naval Air Systems Command, Washington, DC, October 22, 1985.

60. Telephone interview with LCDR Ron Wagner, CASS Program Office, Naval Air Systems Command, Washington, DC, October 22, 1985.

61. Telephone interview with CDR Kalapos, LAMPS Program Office, Naval Air Systems Command, Washington, DC, October 16, 1985.

62. Telephone interview with Bill Woodbury, Operations Research Analyst, Cost Estimating Division, Naval Air Systems Command, Washington, DC, October 22, 1985.

63. Shorey, Russell R., "Managing Downstream Weapons Acquisition Costs," Defense Management Journal, Vol. 12 No. 1, January 1976.

64. Telephone interview with Colonel J. A. Creech (USMC), Program Manager JVX, Naval Air Systems Command, Washington, DC, October 16, 1985.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22304-6145	2
2.	Library, Code 0142 Naval Postgraduate School Monterey, California 93943-5002	2
3.	Defense Logistics Studies Exchange U.S. Army Logistics Management Center Fort Lee, Virginia 23801	1
4.	CDR D. V. Lamm, Code 54Lt Department of Administrative Sciences Naval Postgraduate School Monterey, California 93943-5004	5
5.	LCDR R. W. Smith, Code 54Sx Department of Administrative Sciences Naval Postgraduate School Monterey, California 93943-5004	1
6.	Curricular Office, Code 36 Naval Postgraduate School Monterey, California 93943-5004	1
7.	Commander Naval Air Systems Command ATTN: Captain Vigrass (Air-524E) Naval Air Systems Command Headquarters Washington, DC 20301	1
8.	Commander Naval Air Systems Command Headquarters ATTN: A. M. Piermatteo (Air-552A) Washington, DC 20301	5
9.	Commanding Officer Naval Ordanance Station ATTN: LCDR D. L. Porter Louisville, Kentucky 40208	1
10.	Lockheed ATTN: Al Harcarik) P.O. Box 551 Department 6631 Burbank, California 91520	1

11. Teledyne 1
ATTN: Phil Staats, Plant 27
19601 Nordoff Street
Northridge, California 91326

12. Litton Guidance and Control Systems 1
ATTN: Daniel G. Frank
5500 Canoga Avenue
Woodland Hills, California 91365

13. Commanding Officer 1
Naval Aviation Logistics Center
ATTN: Larry Stahl, Code 633)
Patuxent River, Maryland 20670

14. Debbie Walker, Code 0143C 1
Naval Postgraduate School
Monterey, California 93943-5004

DTIC

END

4-86